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American Inst. of Biological Sciences, Arlington, Va.

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ANALYSIS OF SPECIALIZED PESTICIDE PROBLEMS

INVERTEBRATE CONTROL AGENTS—EFFICACY TEST METHODS

VOLUME III

GENERAL SOIL TREATMENTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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The testing of soil insecticides for efficacy is extremely complex and it would be impossible to put together guidelines for all soil insecticides; therefore, an attempt has been made to pull together some test methods for major pests on a few commodities. The commodities selected are corn, vegetables, sugarbeets, peanuts and tobacco . It would be impossible to cover all pests that might require soil insecticides under each of the commodities chosen.

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peanuts
sugarbeets
tobacco
vegetable crops
radish
cabbage
onion
rutabaga

cauliflower
broccoli
Brussels sprouts
turnip
sweet potato
snap beans
lima beans
dry beans
sweet corn
English or garden pea
cucurbits

corn rootworm
cutworms
wireworms
cabbage maggot
sugarbeet root maggot
Southern corn rootworm
lesser conrstalk borer
granulate cutworm
burrowing bug
tobacco thrips
potato leafhopper
tobacco wireworm
Green June Beetle
Tobacco flea beetle
onion maggot

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ANALYSIS OF SPECIALIZED PESTICIDE PROBLEMS
INVERTEBRATE CONTROL AGENTS - EFFICACY TEST METHODS
VOLUME III
GENERAL SOIL TREATMENTS

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Report To The
Environmental Protection Agency

By The

American Institute of Biological Sciences
Arlington, Virginia 22209

EPA REVIEW NOTICE

This Report has been reviewed by the Office of Pesticide Programs, Criteria and Evaluation Division, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement of recommendation for use.

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GENERAL SOIL TREATMENTS

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INTRODUCTION

The testing of soil insecticides for efficacy is extremely complex and it would be impossible to put together guidelines for all soil insecticides; therefore, an attempt has been made to pull together some test methods for major pests on a few commodities. The commodities selected are corn, vegetables, sugarbeets, peanuts and tobacco. It would be impossible to cover all pests that might require soil insecticides under each of the commodities chosen.

The problems related to compiling generally accepted test methods to provide efficacy data for soil insecticides are many and complex. For example, when dealing with such groups as cutworms, wireworms, grubs, corn rootworms, maggots, and others, one is not working with individual species, but from one to many different species of insects in each of the groups mentioned. Researchers cannot be sure of the number of species that make up a particular complex of insects that might attack a given crop. This makes testing of insecticides very difficult and must be given consideration when one determines the number of test sites that should be included for soil insecticides on a complex of insects such as wireworms, cutworms, grubs, etc. Many times in the past a species of a given insect has actually gone unidentified.

A first endeavor was to review and accept a report form that would be common for all commodities where soil insecticides are being tested. A copy of a suggested form is attached. Determining the efficacy of a particular soil insecticide in soil is a very complex study and for that reason this report form includes necessary data for a complete evaluation of a compound. It is known that factors such as organic matter content, soil type, pH, microorganisms, soil moisture - to mention a few - have a tremendous effect on the performance of soil insecticides. The number of tests that must be conducted to determine the efficacy of a particular insecticide is dependent upon the variability of the soil in which the pest organisms are found.

Complete published methods for efficacy testing of soil insecticides are for the most part unavailable. Test methods described herein were compiled from applicable reports of time tested procedures.

It is recognized that protocols for testing soil insecticides must not be static and a great amount of flexibility must remain for determining the efficacy of soil insecticides. For example, the plot size that should be used may vary from a one row plot 20 feet long to a plot as large as an acre in size, depending upon the objectives of the particular experiment. Also, the plot size is going to be dependent upon such variables as uniformity of the soil, magnitude of the infestation, and equipment available to the scientist. As a rule, the smaller the plot size, the less variability one would encounter and likewise, the less number of replicates that would be needed to obtain statistically sound data. Plot size should be given serious consideration when one is working with insects which might migrate from plot to plot. Methods of application also are dependent upon the particular material involved and the availability of material. Likewise, as newer materials become available, new methods of application must be given consideration. It is unwise to limit the rate of application per acre. The rate of application per acre is dependent upon the efficacy of the compound, economics of the particular material, and the hazards which might be encountered from the use of the material. Future compounds may dictate some very unusual rates compared to those commonly used today. The rate of application really should not be considered a function of the test method. However, rates tested should be given in pounds active ingredient per acre (kilograms per hectare). When row applications are made, rates should be expressed as ounces per linear foot of row (grams per meter). In such cases, row spacing should always be given.

PESTICIDE TEST REPORT

The following information should be provided as completely as applicable in reporting the results of efficacy tests:

CROP (AND VARIETY) ____________________

PEST(S) (AND STAGE - e.g., LARVAE, ADULT) ____________________

COOPERATOR'S NAME ____________________

LOCATION ____________________

YEAR ____________________

COMPOUND ____________________

FORMULATION AND LOT OR BATCH NUMBER ____________________

SPECIFIC METHOD OF APPLICATION ____________________

NUMBER OF APPLICATIONS ____________________

RATE OF ACTIVE INGREDIENT APPLIED ____________________

TOTAL FORMULATION AND TOTAL VOLUME OF SPRAYS APPLIED PER ACRE OR PER 100 GALLONS ____________________

PLANTING DATE ____________________

PLOT SIZE AND ROW SPACING ____________________

NUMBER OF REPLICATES ____________________

PRESENCE OR ABSENCE OF PHYTOTOXICITY ____________________

PERFORMANCE (INSECT COUNTS, ROOT AND LEAF RATINGS, PRE-TREATMENT COUNTS WHERE APPLICABLE, ETC.) ____________________

____

SOIL TYPE WHERE SOIL PESTICIDES ARE APPLIED ____________________

YIELD DATA ____________________

WEATHER CONDITIONS DURING TEST ____________________

OTHER PESTICIDES USED ON SAME PLOTS ____________________

COMPATIBILITY WITH OTHER PRODUCES ____________________

PRESENCE OF WILDLIFE AND BENEFICIAL INSECTS (IDENTIFY) ____________________

EFFECTS ON WILDLIFE OR BENEFICIAL INSECTS ____________________

ANY ADDITIONAL COMMENTS OR OBSERVATIONS ____________________

____

CORN

Corn is attacked by several soil inhabiting insect pests that include corn rootworms, cutworms, wireworms, seed corn maggot, seed corn beetles, white grubs, corn root aphids, and billbugs. Populations of these soil insects are controlled by applications of insecticides to the soil. Although the major proportion of the soil insecticide treatments on corn is for soil insects, some above-ground insects such as armyworm, European corn borer, and south-western corn borer are controlled by systemic action of soil applied insecticides. Although all of these insects can become a significant problem on corn, the major soil insects based on pounds of soil insecticide used are the corn rootworms, cutworms, and wireworms.

The complex association of these pests with the soil adds another dimension to studies on insect biology and insecticide efficacy. In addition to insect population parameters and environmental factors, soil factors such as soil type, texture, organic matter, and drainage must be evaluated.

The test methods reported are compiled from several sources. They are continually changing as new techniques and methodology for insect detection and soil analysis are developed. Consequently, an appendix of test methods must be routinely updated to reflect these changes.

Corn Rootworm

The major species of corn rootworm larvae attacking the root systems of corn are the southern corn rootworm (*Diabrotica undecimpunctata howardi* Barber), northern corn rootworm (*Diabrotica longicornis* (Say)) and the western corn rootworm (*Diabrotica virgifera* LeConte). Although specific test methods vary, they contain much similarity.

Site Selection:--Site selection for field tests of efficacy is based on severe corn rootworm damage the preceeding year (8), on a fall egg population estimate (3,8), on the presence of numerous adults in August of the preceding year (5,6,8), or on a combination of these techniques. In addition, trap crops are often used (5,6,7, Exhibit II). The trap crop consists of corn which is planted later than normal in an area of high beetle populations. The beetles are attracted into the trap crop and oviposit there.

Crop and Plot Management:--A commercially adapted variety is selected which is susceptible to rootworm feeding and is noted for poor root regeneration (5,6,7,8,10, Exhibit II). Row spacings and plant populations are those consistent with current recommended agronomic practices (3,5,6,7,8, Exhibit I, II).

Plot management techniques are generally the same as employed for normal corn production at the test site (3,6,7,8, Exhibit I, II). To evaluate the efficacy of soil insecticides for control of corn rootworm larvae under normal field conditions, it is important to maintain fertility, weed control and planting procedures similar to those accepted for good corn production. Generally, the corn rows are planted parallel to the old rows (8) and coincide with those at the test site which facilitates normal field operations (fertilization, cultivation, etc.).

Test Procedures:--Standard statistical designs are employed as necessary to meet the objective of the experiment (1,3,4,5,6,7,8,9,10,11, Exhibit I, II). Generally, 4 replications are adequate for field efficacy studies.

Insecticidal evaluations are based on plots from 1-8 rows wide (1,3,5,6, 7,8,9,10, Exhibits I, II) and from 25'-100' (7.6-30.5 meters) long (1,3,5,6,7, 10, Exhibit I, II). Usually, the test site is located within a field of larger dimension than the test plot to minimize any border effects. When this is not feasible, borders range from 2-4 rows around the edge of the field. No evaluations are made in the first or last 10-15 ft. (3.05-4.6 meters) of each plot to allow for variations in treatments because of equipment starting or stopping (6,8).

For granular soil insecticides, the methods for applying soil insecticides range from a modified V-belt seeder to a commercial planter equipped with commercially available granular insecticide boxes (1,3,6,7,8,10, Exhibit I, II).

For the liquid formulations, applications are usually made with a modified spray delivery system (5,7,8), which is hand carried or planter mounted.

Because applications in a 7 inch (17.5 cm) band centered over the corn row and in front of the presswheel have been shown to be the most effective (9), initial efficacy is generally based on this type of application (2,7,8, Exhibit II). Other methods of application commonly evaluated are in-furrow at planting (2,7,8, Exhibit I), preplant broadcast incorporated (5,6,9, Exhibit I) and combinations with liquid fertilizers at planting (5,6,7,8).

Both granular and liquid soil insecticide applications for control of corn rootworm larvae are made at planting and/or at first cultivation (3,4,5,6,7,8, 10, Exhibit I). Planting time applications are consistent with normal planting dates and often include some planting dates which are early and/or late for the area (3,4,6,7,8).

All efficacy tests on soil insecticides contain untreated controls and at least one standard insecticide treatment for comparison in each replication of the test.

Natural infestations are relied upon for these tests. To enhance the probability of an infestation, the procedure as outlined under Site Selection is employed (i.e., egg counts, trap crops, etc.).

Evaluations:--The efficacy of a soil insecticide for control of corn rootworm larvae is based on larvae counts, (3,7, Exhibit II), root damage ratings (4,5,6,7,8,10, Exhibit II), adjusted root damage rating (5), root damage index (7), or a combination of 2 or more of these methods. Although yield determinations are used, usually efficacy is measured by one or more of the above methods. The most utilized method is the root damage rating.

Evaluations are made at the time of peak root feeding damage. Oftentimes, evaluations commence when the majority of the insect population is in the pupal stage, except for the southern corn rootworm where seed and seedling damage is evaluated (Exhibit I).

Most data are analyzed according to standard Analysis of Variance (ANOVA) procedures. Differences among means are determined by numerous methods (LSD, Duncan's New Multiple Range Test, etc.) (3,4,5,6,7,8,10, Exhibits I, II). Most inferences are made at the 95% confidence level.

Effectiveness:--To be judged effective against the corn rootworm larvae, a soil insecticide must compare favorably with currently recommended insecticides (3,4,5,6,7,8,10, Exhibit I, II). In addition, it must show no adverse effects on yield or no phytotoxicity. Phytotoxicity is determined by general plant vigor and/or stand counts (2,6,7,8, Exhibit I, II). Phytotoxicity studies can be independent of insecticide efficacy studies (2).

References

(Modified references follow this section on References and Exhibits)

1. Apple, J. W. 1961. Appraisal of insecticidal granules in the row against damage by the northern corn rootworm. *J. Econ. Entomol.* 54(5):833-36.

2. Apple, J. W. 1971. Response of corn to granular insecticides applied to the row at planting. *J. Econ. Entomol.* 64(5):1208-11.

3. Apple, J. W., E. T. Walgenbach, and W. J. Knee. 1969. Northern corn rootworm control by granular insecticide application at planting and cultivation time. *J. Econ. Entomol.* 62(5):1033-35.

4. Hills, Tom M., and Don C. Peters. 1971. A method of evaluating postplanting insecticide treatments for control of western corn rootworm larvae. *J. Econ. Entomol.* 64(3):764-65.

5. Hills, Tom M., and Don C. Peters. 1972. Methods of applying insecticides for controlling western corn rootworm larvae. *J. Econ. Entomol.* 65(6):1714-18.

6. Hills, Tom M., Don C. Peters, and Walter G. Lovely. 1972. Application equipment and techniques used in the evaluation of granular insecticide for control of western corn rootworm larvae. *J. Econ. Entomol.* 65(4):1116-19.

AS MODIFIED: J. J. Tollefson, Assistant Professor, Department of Entomology, Iowa State University, Ames, Iowa.

7. Mayo, Z. B. 1975. A five-year comparison of insecticides applied to control larvae of western and northern corn rootworm. Institute of Agriculture and Natural Resources, University of Nebraska - Lincoln. *Agric. Exp. Sta.* SB 535.

AS MODIFIED: Z. B. Mayo

8. Musick, G. J. 1974. Efficacy of liquid starter fertilizer - insecticide combinations for control of resistant northern corn rootworm larvae. *J. Econ. Entomol.* 67(5):668-70.

AS MODIFIED: G. J. Musick

9. Musick, G. J. 1975. Best corn rootworm control with banded insecticides. *Ohio Rep.* 60(1):3-5.

10. Musick, G. J., and M. L. Fairchild. 1967. Preliminary study on some of the factors affecting control of western corn rootworm larvae with soil insecticide. *J. Econ. Entomol.* 60(6):1522-25.

11. Musick, G. J. and M. L. Fairchild. 1968. Comparison of application rates of some soil insecticides for control of western corn rootworm larvae in Missouri. *J. Econ. Entomol.* 61(5):1188-89.

Exhibit I. Test Method for Southern Corn Rootworm on Corn. E. H. Floyd. Professor, Department of Entomology, Louisiana State University, Baton Rouge, Louisiana.

Exhibit II. Test Method for Northern and Western Corn Rootworm on Corn. D. D. Walgenbach. Associate Professor, Department of Entomology, South Dakota State University, Brookings, South Dakota.

Modified References

6. Hills, Tom M., Don C. Peters, and Walter G. Lovely. 1972. Application equipment and techniques used in the evaluation of granular insecticide for control of western corn rootworm larvae. *J. Econ. Entomol.* 65(4): 1116-19.

AS MODIFIED: J. J. Tollefson, Assistant Professor, Department of Entomology, Iowa State University, Ames, Iowa.

Test Site:--

Insect infestation - A test site is selected primarily on the basis of the number of corn rootworm that are anticipated will be present during the test year. Population estimates obtained during the fall of the previous year are used to select fields that are expected to have a sufficiently high population of larvae to provide a good test of the efficacy of the chemicals used. The sampling methods used are adult counts during the month of August and egg counts in October.

Topography - The test plots used are a single row wide. Consequently, appreciable soil movement due to erosion that may carry along the insecticides being evaluated cannot be tolerated. To avoid this, the area of a rootworm infested field that is selected for an insecticide evaluation study is located in an area of the field with minimum slope.

Border effects - The plots are positioned within a field so as to minimize border effects. The only restriction on the placement, other than slope mentioned previously, is that the plot must be readily accessible to farm equipment from at least one point.

Climatic Conditions:--The field evaluations of insecticides for the control of corn rootworms are designed to simulate typical agronomic practices and as such are subject to the same climatological restrictions as normal field work.

Test Crop:--

Variety - A commercially produced hybrid is used that is considered "susceptible" to rootworm damage. A hybrid is considered susceptible if it is prone to lodging under rootworm infestations. This is generally the result of having a small root system with little secondary root growth.

Row spacing - The row spacing used by the cooperator is matched so that all tillage operations normally employed are also applied to the test plot.

Plant population - A plant population slightly higher than the state average is used. The current population, at planting time, being used is 22-24,000 plants per acre (54,362-59, 304 plants per hectare). This practice is followed so that the chemicals are evaluated under conditions normally employed that provide the most stress on the performance of the insecticides. The higher plant populations cause more competition and the root systems are not as fully developed. This makes any loss of roots more serious.

Test Plot Management:--

Plot management procedures to insure infestations - Rather than relying totally on chance infestations several trap crops are planted across the state. These trap crops consist of late planted corn that attracts the beetles by producing fresh silks, a preferred food source, late in the season to lure the insects from surrounding fields in which the silks have dried and are no longer available.

Planting procedures - The row spacing and direction used by the cooperator are duplicated and the rows are aligned as closely as possible to those in the rest of the field. This allows all tillage practices employed after the plots have been established to be applied to the plots so that the tests are representative of typical agronomic practices.

Fertility procedures - The cooperator treats the plot area in exactly the same way up to planting time, using the same fertility procedures.

Weed control - Herbicides are generally used to control weeds. If the herbicides are not applied during the planting operation, the farmer will apply them using his own equipment at the same time as he treats the rest of the field. If the farmer applies his herbicide as he plants, the herbicide is applied by the researchers at the time the plots are established. The herbicide used is selected to fit into the grower's cropping practices. If the field in which the plots are located are rotary hoed or cultivated, the plots are tilled just as though it were part of the field.

Procedures:--

Statistical design -

Design: randomized complete block
Replications: 4

Locations required - New insecticides are evaluated at 3 locations across the state to test the chemicals under several sets of environmental conditions and tillage practices. Using more than one location guards against failure to collect any data due to the lack of establishment of an insect infestation.

Specific plot plan -

Number and length of rows: The treatments within each replication are applied to a single row 100 ft. (30.5 meters) long.

Border effect: A minimum of four guard rows are planted on each side of the test area at the time the plot is planted and the plot is nested within a large field to avoid border effects.

Treatment dates: Treatments are applied at planting time.

Distance between replications: No evaluations are made in the first or last 15 ft. (4.6 meters) of a plot to allow for variability in the treatments due to the equipment starting and stopping.

Specific treatment procedures -

Methods: The methods and equipment used have been described in the publication:

Hills, T. M., D. C. Peters, and W. G. Lovely. 1972. Application equipment and techniques used in the evaluation of granular insecticides for control of western corn rootworm larvae. *J. Econ. Entomol.* 65:1116-1119.

Rate of application: Rate of application depends on the formulation and toxicity of each specific insecticide.

Stage of crop at treatment: Planting time.

Time of applications: Chemicals are applied at planting time. The specific time this occurs will vary depending on weather conditions. It may begin as early as the third week of April and progress until the end of May. It is usually advised to have planting completed by May 15, however, so that full advantage of long season hybrids may be realized, some replanting occurs much later than this.

Controls: An untreated control and standard insecticide treatments are included in each replication at all locations to serve as standards.

Infestation procedures -

Natural: Tests are located on privately owned land that has shown a potential rootworm hazard based on adult and egg-counts taken the previous year.

Trap crops: Trap crops of late planted, mixed maturity corn are planted on state owned farms in an attempt to draw the rootworms into these fields. Due to the limited distance over which the rootworms are attracted, this procedure produces variable results and reliance on natural infestations is still required.

Evaluations:--

Damage evaluations -

Root damage: The amount of damage to the root systems of five plants in each treatment within each replication is characterized by using a root rating scale ranging from 1 (no damage) to 6 (severe damage). The root rating scale has been described by Eiben (Eiben, G. J. 1967. A comparison of methods used in evaluating corn for corn rootworm resistance. Ph.D. Diss., Iowa State Univ., Ames, Iowa. 198 pp.). It has also been cited in a paper by Hills and Peters (Hills, T. M., and D. C. Peters. 1971. A method of evaluating postplanting insecticide treatments for control of western corn rootworm larvae. *J. Econ. Entomol.* 64:764-765). The average root rating within a replication is computed for each treatment by taking the arithmetic mean of the 5 individual ratings.

Yield: The average yield for each treatment at each location is computed by randomly hand harvesting 1/1000 of an acre (1/2471 of hectare) for each treatment within each replication and computing the arithmetic mean of the 4 observations. The average is adjusted to yield per acre of No. 2 shelled corn based on its moisture content.

Evaluation intervals -

Root rating: The amount of root damage is evaluated at pollen shed. This is when the maximum amount of root growth has occurred and the majority of rootworm feeding has been completed.

Yield: The yields are determined as soon as the moisture content in the grain drops below 35%. This normally occurs during October or November.

Analysis of data -

Procedures: Analysis of variance is used to determine if any differences occur between mean root ratings or between average yields within each location and also between the overall means computed using all locations. Differences between individual means are identified using Duncan's new multiple range test.

Probability level: $P<0.05$.

Phytotoxicity:--

Evaluation - The average number of plants per 1/1000 of an acre (1/2471 of a hectare) is determined for each treatment at each location.

Time interval - The time interval starts as soon as the plants have emerged and become well established, usually from mid to late June.

Analysis - Analysis of variance is used to determine if there are any differences between the means. Differences between individual means are identified using Duncan's new multiple range test.

Probability level - $P<0.05$.

Effectiveness:--The minimum requirements for an insecticide to be judged effective is that it must consistently protect the roots from damage as well or better than the materials currently recommended while having no phytotoxic effects on the plant.

Reporting Procedures:--A preliminary report is prepared following root damage evaluations that include only the statistical evaluations of the phytotoxicity and root damage data. A final report is issued after harvest that includes: a description of the evaluation procedures used; field data sheets that contain the descriptive information for each location; tables of means for the phytotoxicity, root rating and yield data with differences detected by Duncan's test identified for all locations and combined over locations when similar tests were conducted at more than 1 location; and tables containing daily maximum/minimum temperature and precipitation data. The data included in the final report is complete enough to provide all the information requested on the EPA list required for registration except: lot or batch number of chemical, compatibility of formulation with other products, presence of wildlife and beneficial insects, and effects on wildlife and beneficial insects.

7. Mayo, Z. B. 1975. A five-year comparison of insecticides applied to control larvae of western and northern corn rootworm. Institute of Agriculture and Natural Resources, University of Nebraska - Lincoln. *Agric. Exp. Sta.* SB 535.

AS MODIFIED: Z. B. Mayo

Test Site:--

Agronomic factors - Where possible, soils with high sand content are avoided as they adversely affect rootworm larval survival.

Topography - Well drained areas.

Fields completely surrounded with fields planted to continuous corn are preferred.

Test Crop:--

Variety - Corn hybrids adapted to the area with poor root regeneration capabilities are preferred.

Row spacing - 30 to 40 inch (76.2 to 101.6 cm) row spacings.

Plant population - 16,000 to 24,000 plants/acre (39,536 to 59,304 plants/hectare). Where root pull resistance is used as a damage index, plant spacings of not less than 10 inches (25.4 cm) apart are preferred regardless of the row spacing.

Test Plot Management:--

Special management - Where possible, a plot should be planted to trap corn (late planted corn), the previous year. Appropriate planting dates vary with location but the corn should be pollinating in mid-to-late August to attract ovipositing females from surrounding areas. Mixed maturities of hybrids or inbred lines planted together are best.

Normal planting procedures.

Normal irrigation and fertilization procedures.

Procedures:--

Statistical design -

Several designs are used with the most common being the randomized complete block. However, depending on the particular circumstance of a test several other designs are useful including split plots, lattice designs, latin square, etc. Analysis of duplicate experiments over locations is by means of combined analyses of randomized complete block experiments.

A minimum of four replications.

Location required - One location is required but results vary from place to place and duplications in other areas are highly desirable. Five locations are used in Nebraska for certain tests.

Specific plot plan -

One row plots, 50 ft. (15.2 meters) long are used for band insecticide studies. Three, four, six and 10 row plots are used for broadcast experiments and other studies.

A minimum of four rows for a border between experiments.

Treatment dates:

Planting time larval control - apply at planting, earlier planting dates preferred (April 25 - May 7).

Cultivation - apply at first cultivation and prior to June 15 in most years.

Distance between replications: Minimum of 5 feet (1.5 meters).

Other consideration: Where possible keep replication no larger than 35 ft. (10.7 meters) wide (14 rows or 14 one-row treatments) X 50 ft. (15.2 meters) long to avoid as much with-in plot population variation as possible.

Specific treatment procedures -

Granule application method:

Planting time treatments -

V-Belt Seeder with drops (6" (15.2 cm) bander) in front of press wheel calibrated for 50 ft. (15.2 meters) row. Amount of insecticide required for 50 ft. (15.2 meters) of row is weighed and placed into a container, prior to going to the field. In the field the material is spread evenly on the V-belt and applied to the plot by the planter.

Noble Metering Units calibrated according to speed. Used for band application and in-seed furrow application.

Liquids are applied by a one quart, CO_2 pressurized sprayer mounted on the planter with a 7" (17.8 cm) band in front of the press wheel. (One unit/planter unit).

Rate of application: Band and in-furrow - Depends on material but most treatments are applied at 3/4 - 1# AI/A (40" row) (.841 -1.12 kg/hectare) rates.

Stage of crop at treatments:

Most applications are at planting time.

Cultivation treatments are applied before June 15 for best control. Corn growth stages range from 1 to 2 based on the Iowa State University scale of corn growth stages.

Time of applications: Planting - April 25 to May 20.

Controls: An untreated control and a treated control are included in each test. The treated control (treatment standard) presently used in Nebraska studies is carbofuran 10G-1.2 ounces AI/1000 linear ft. of row (34.05 g./304.8 meters of row).

Infestation procedures: Use of trap corn in the field previous years. Trap corn in Nebraska should be planted from June 15 - 20.

Evaluations:--

Damage evaluations -

Damage ratio: (Beginning in 1975) - A damage ratio will be calcualted for each treatment based on the untreated entry or entries.

Damage ratings:

Plant stand in 30 ft. (9.1 meters) of row will be used to evaluate seedling phytotoxicity.

Two systems are used depending on the experiment involved, one or both of the following evaluation techniques will be employed. In areas where there is considerable soil variability, only root damage ratings will be used.

> Root pull resistance on 10 plants in each treatment row following methods described by: Ortman, E. E., D. C. Peters, and P. J. Fitzgerald. 1968. Vertical-pull technique for evaluating tolerance of corn root systems to northern and western corn rootworm, *J. Econ. Entomol.* 61(2):373-75.
>
> Root damage ratings will be made for 5 plants in each treatment row. A modified 1-6 (Hill and Peters 1971) damage scale is used.

Insect counts: In most experiments only general area counts will be made. In specific experiments insect counts will be made by:

Digging 4 plant samples/treatment (7" (17.8 cm) cube of soil surrounding roots) and floating larvae.

Placing 6' X 6' X 6' (19.7 X 19.7 X 19.7 meters) saran cages over 2 rows and collecting emerging beetles to estimate larval populations.

Yield: Hand harvesting 20' or 30' (6.1 - 9.1 meters) of row per treatment and converting to number of bushels of #2 corn/acre.

Lodging: The number of plants leaning 30° or more at the base are considered lodged. Twenty or 30' (6.1-9.1 meters) of row are counted per treatment.

Evaluation intervals - Larval damage evaluations are made at the time of peak damage. Depending on the year, it ranges from July 7-20.

Analysis of data -

Standard analysis of variance and Duncan's Multiple Range tests are employed on all tests. Analysis for duplicate experiments at other locations is accomplished by combined analysis over locations.

Probability level: .05 level.

Phytotoxicity:--

Type -

Seed or seedling damage by planting time applications: No. plants/30' (9.1 meter) row and evaluate about 2 week post planting.

Foliage damage by post-planting applications: % affected plants.

Effectiveness:--

Minimal evaluation necessary to be judged effective.

Root damage ratings: Root damage ratings in excess of 3.0 are considered economic damage.

Root pull resistance: Pull resistance is related to the conditions of the soil at evaluation time and all values are considered in relation to the other entries and the standards in each experiment.

Yield: Yield reductions in excess of 15% are usually considered economic (depending on year). Smaller yield differences are economic but are difficult to determine whether the differences are due to treatment effects or experimental error.

Reporting Procedures:--In most of the items listed in this outline are included in the report.

8. Musick, G. J. 1974. Efficacy of liquid starter fertilizer - insecticide combinations for control of resistant northern corn rootworm larvae. *J. Econ. Entomol.* 67(5):668-70.

AS MODIFIED: G. J. Musick

Site Selection:--Test site selection is based on fall egg count survey. Ten composite 1 pint soil samples are taken from each potential field. A potential field is defined as a field with high beetle population the preceeding August or a field with severe root lodging. Egg counts must average over 25/pint (25/473.25 ml) of soil before selection as a test site.

Crop and Plot Management:--A commercially adapted variety with minimal root regeneration potential is selected. Row spacings and fertility practices are those normally employed by the cooperator. For damage evaluations, plant populations are maintained at 16-20,000/acre (39,536-49,420/hectare). Corn rows are planted parallel to previous years rows or consistent with the cooperator's planting.

Test Procedures:--At least 1 location is essential. These tests are repeated for 2-3 years.

Evaluations:--

Root ratings are used to measure efficacy. Root ratings on a scale of 1-6 or 1-9 are used. The rating scheme for 1-6 is as outlined by Hills and Peters, 1971.

Hills, Tom M., and Don C. Peters. 1971. A method of evaluating postplanting insecticide treatments for control of western corn rootworm larvae. *J. Econ. Entomol.* 64(3):764-65.

Rating scheme for 1-9 is:

1 - No feeding damage
2 - Light feeding damage, no pruning
3 - Feeding damage with only an occasional pruned root (1-2 pruned roots per mass)
4 - Feeding damage and some pruning (less than 10% of roots pruned 2-3 inches)
5 - Feeding damage and moderate pruning (10-50% of roots pruned 2-3 inches)
6 - Feeding damage and severe pruning (more than 50% of roots pruned)
7 - 1 node of roots destroyed (root stubs 1 inch or less)
8 - 2 nodes of roots destroyed
9 - 3 nodes of roots destroyed

Evaluations:--Phytotoxicity is routinely taken on all experimental compounds. In-furrow placement of soil insecticides is often investigated, especially in first such placement. Phytotoxicity is measured by plant population reduction over untreated checks.

Cutworms

Although several species of subterranean cutworms have been known to attack corn, the 10 major species include black cutworm, *Agrotis ipsilon* (Hufnagel); bristly cutworm, *Lacinipolia renigera* (Stephens); bronzed cutworm, *Nephelodes minians* Guenee; dark-sided cutworm, *Euxoa messoria* (Harris); dingy cutworm, *Fletia subgothica* (Haworth); glassy cutworm, *Crymodes devastator* (Brace); granulated cutworm, *Feltia subterranea* (Fab.); army cutworm, *Euxoa auxiliaris* (Grot.); variegated cutworm, *Peridroma saucia* (Hubner); and sand hills cutworm, *Euxoa*

detersa (Walker). The test methods for soil insecticides remains rather consistent over the subterranean cutworm complex. However, efficacy may vary with the genera and/or species encounterd.

Site Selection:--Most test sites are selected on the basis of field reports of economic populations of cutworms (4,5, Exhibits 3,4,5). Prediction and sampling techniques have not been refined enough to allow selection prior to the occurrence of the pest. An exception is when artificial infestation procedures are used (1, Exhibit 4). Under these conditions, site selection is restricted to normal corn producing soils.

Crop and Plot Management:--A commercially adapted variety is selected. Row spacings and plant populations are consistent with current agronomic practices (Exhibits 3,4,5). For these evaluations, procedures similar to those currently being used at the test site (i.e., cooperator, fertilization, cultivation, etc.) are maintained.

Test Procedures:--Although various experimental designs are used depending on experimental objective, most tests employ the standard randomized complete block design with 3 or more replications (1, Exhibits 3,4,5).

Efficacy test are based on plots from 1-10 rows wide and from 10-100 ft. (3.05-30.05 meters) long (1, Exhibits 3,4,5). To minimize border effects, sampling is restricted to the center portion of a plot (4, Exhibits 4,5).

Cutworm tests are conducted with granule, spray and/or bait formulations. Granular soil insecticides are applied from commercially available granular applicators or specially modified granular applicators (1,4, Exhibits 3,4). Liquid formulations are applied with modified spray delivery applicators which are calibrated for proper rates and are hand carried or tractor mounted (Exhibits 3,4). Bait formulations are applied by hand, or through commercially available gravity feed applicators (Cyclone-Seeder® type).

Methods of applying soil insecticide for control of subterranean cutworms include banding in a 6-14 inch (15.2-35.6 cm) band in front of the presswheel at planting (1,5, Exhibits 4,5), banding of a directed spray at post plant, preplant (incorporated) broadcast (1,4, Exhibit 4), or post plant (not incorporated) broadcast (1,4, Exhibit 4).

All tests include an untreated control and at least one standard insecticide treatment (1,5, Exhibits 3,4,5).

If plots are artificially infested with cutworm the following procedure is followed. At present, this procedure is used for tests with black cutworms only. Insecticides are applied as previously outlined. After application, 6" (15.2 cm) aluminum barriers are installed (1,3, Exhibit 4). The barriers enclose an area consisting of 1-2 rows wide and from 3-7 feet (0.9-2.1 meters) long (1,3, Exhibit 4). There is one barrier for each treatment and replication. The experimental design is as previously outlined. After the barriers are erected, 4th or 5th-stage larvae are released in each barrier. The number of cutworms released in each barrier. The number of cutworms released in a barrier is dependent on the number of corn plants within the barrier usually 1 larva/plant (1, Exhibit 4). These tests are usually confined to corn that is in the 2-leaf stage (1, Exhibit 4). Releases are usually made the evening following the application of the insecticide (Exhibit 4), or by some other method (1).

Evaluations:--Preliminary screening for efficacy of a soil insecticide for control of subterranean cutworms can be conducted in the greenhouse (2). Field efficacy is determined by stand counts (4,5, Exhibits 4,5), plant damage (Exhibits 3,4), plant weight (1), and yield (4, Exhibits 3,5). Because most evaluations are on natural occurring field infestations, the number of damaged and undamaged plants in each plot are determined before treatment with an insecticide (Exhibits 3,4,5). Control is based on the % change in these damaged plants after treatment (Exhibits 3,4,5). Evaluations are made once or at regular intervals ranging from daily to bi-monthly through pupation (1,4, Exhibits 3,4,5).

Most data are analyzed according to standard ANOVA procedures. Differences among means are determined by numerous methods (LSD, DNMRT) (1,4,5, Exhibits 3,4,5). Most inferences are made at the 95% confidence level.

Effectiveness:--To be judged effective, an insecticide must have plant population (stand counts) which are significantly above the untreated control or perform favorably with a standard insecticide treatment. If effective, the insecticide must show no adverse effects on yield or no phytotoxicity (1,5, Exhibits 3,4,5).

References

1. Apple, J. W. 1967. Insecticidal control of regulated populations of black cutworm on corn. *J. Econ. Entomol.* 60(6):1612-15.

2. Sechriest, R. E. 1966. A simple technique for screening insecticides to control black cutworm larvae, *Agrotis ipsilon* (Hufnagel). *J. Econ. Entomol.* 59(2):485.

3. Sechriest, R. E. 1967. Evaluating artificial infestations of black cutworms. *J. Econ. Entomol.* 60(4):923-5.

4. Sechriest, R. E. 1967. Studies on black cutworm control. *Proc. N. C. Branch, ESA.* 22:89-93.

5. Sechriest, R. E. 1974. Chemical control of *Euxoa detersa* in corn. *J. Econ. Entomol.* 67(1):138-9.

Exhibit 3. Test Method for Cutworms on Corn. Z. B. Mayo. Assistant Professor, Department of Entomology, University of Nebraska, Lincoln, Nebraska.

Exhibit 4. Test Method for Black Cutworm on Corn. G. J. Musick. Associate Professor, Department of Entomology, Ohio Agricultural Research and Development Center, Wooster, Ohio.

Exhibit 5. Test Method for Cutworms on Corn. J. J. Tollefson. Assistant Professor, Department of Entomology, Iowa State University, Ames, Iowa.

Wireworms

Although the number and distribution of the various species of wireworm are not known, the test methods for the different species are quite similar. However, efficacy may vary with the genera and/or species encountered.

Site Selection:--The selection of a test site is based on fields with a previous history of wireworms (2,3, Exhibits 6,7), current report of wireworm damage (2, Exhibit 8), corn following old established sods, wireworm counts (1), baiting with corn and wheat (Exhibit 7), or a combination of one or more of these selection procedures. Generally, wireworm infestations are found to be more severe in fields with soils of a more sandy texture (3).

Crop and Plot Management:--A corn variety adapted for use in the area of the test is selected. Row spacings and plant populations are consistent with current agronomic practices (3, Exhibits 7,8). To evaluate soil insecticides under field conditions, procedures similar to those currently being used at the test site (i.e., fertilizer, cultivation, etc.) are maintained.

Test Procedures:--The standard statistical design composed of a randomized complete block, split plot, or other statistical methods with 4 or more replications is used (1,2,3, Exhibits 6,7,8).

Insecticidal evaluations are based on plots from 1-8 rows wide (1,2,3, Exhibits 6,7,8) and ranging from 50 feet (15.2 meters) long to the entire length of the test field (1,2,3, Exhibits 6,7,8). No evaluations are made in the first or last 10-20 feet (3.05-6.1 meters) of each plot (Exhibit 8).

Granular soil insecticides are applied with commercially available insecticide boxes which are mounted on a corn planter (1,3, Exhibits 7,8) or are modified for broadcasting.

Methods of application include banding of the insecticide over the corn row (Exhibits 6,7,8), in-furrow (3, Exhibits 7,8), as a seed treatment (1,3) and/or as an incorporated broadcast preplant application (1,2,3, Exhibits 6,7,8).

Although most treatments are applied preplant or at planting (1,3, Exhibits 7,8), some treatments are applied post-planting (2).

Insecticidal applications are usually made at the normal planting date for a given location or area, unless the treatments are applied after an economic infestation has been identified (1, 2, 3, Exhibits 6, 7, 8).

All tests for insecticidal efficacy must include an untreated control and at least one standard insecticide treatment for control of wireworm larvae (1, 2, 3, Exhibits 7, 8).

These tests are dependent on natural insect infestations. To increase the probability of an infestation, the site selection procedures outlined previously is followed, including multiple locations.

Evaluations:--The efficacy of a soil insecticide for control of wireworm larvae is determined by stand counts (1, 2, 3, Exhibits 6, 7, 8), wireworm larval population determinations (3 and Exhibit 7), yield (1, 2, 3, Exhibits 7, 8), or a combination of these methods.

Evaluations usually are made at emergence of the corn plants (1, 2, Exhibits 6, 7), and/or from 2-4 weeks after planting (3, Exhibits 7, 8). The first evaluation furnishes information on seed attack; whereas, the second evaluation discloses the degree of seedling damage. Because stand counts are used in evaluations, it is important to have a planting unit that gives uniform and consistent seed drop.

Standard analysis of variance techniques are used in analyses of the data. Usually, differences among means are determined by either Duncan's New Multiple Range Test (DNMRT) or the Least Significant Difference (LSD). Most inferences are based on a 90-95% probability level (1, 2, 3, Exhibits 6, 7, 8).

Effectiveness:--To be judged effective against wireworm larvae, a soil insecticide must have plant populations (stand counts) which are significantly better than the untreated control and compare favorably with standard insecticide treatment. Additionally, it must show no adverse affects on yield or no phytotoxicity. Phytotoxicity is measured by plant vigor and/or plant population reductions.

References

1. Apple, J. W., F. E. Strong, E. M. Raffensperger. 1958. Efficacy of insecticidal seed treatments against wireworms on lima beans and corn. *J. Econ. Entomol.* 51(5):690-92.

2. Keaster, Armon J. and Mahlon L. Fairchild. 1960. Occurrence and control of sand wireworm in Missouri. *J. Econ. Entomol.* 53(5):963-4.

3. McBride, Dean K. 1971. Wireworm control in corn. *North Dakota Farm Res.* 29(1):12-16.

Exhibit 6. Test Method for Wireworms on Corn. W. G. Genung. Professor Agricultural Research and Education Center, Belle Glade, Florida.

Exhibit 7. Test Method for Wireworms on Corn. Z. B. Mayo. Assistant Professor, Department of Entomology, University of Nebraska, Lincoln, Nebraska.

Exhibit 8. Test Method for Wireworms on Corn. J. J. Tollefson. Assistant Professor, Department of Entomology, Iowa State University, Ames, Iowa.

PEANUTS

Peanuts are attacked by a complex of soil insect pests that include the lesser cornstalk borer, southern corn rootworm, granulate cutworm, and burrowing bug. Other soil inhabiting pests are important in localized areas such as wireworms, white-fringed beetle, and white grubs.

Foliage feeding insects such as the tobacco thrips and potato leafhopper are commonly controlled with soil-applied systemic insecticides.

Soil types and soil moisture have a marked influence on the pest status of soil insects. For this reason the lesser cornstalk borer is a major pest in sandy soils while the southern corn rootworm favors poorly drained, heavy, soils. Insecticide tests for soil insects attacking peanuts should therefore be established in areas having a history of damage from the desired pest species.

Southern corn rootworm, Spotted cucumber beetle, *Diabrotica undecimpuncta howardi* Barber

The larva of the southern corn rootworm tunnels into the pegs (immature peanuts with unsculptured hull) and pods (hull sculptured) causing a direct loss in harvestable peanuts.

Since the adult beetle has been collected on more than 200 host plants (3) sampling for adults to estimate damage threshold is not very effective. Estimation of larval populations is further complicated by the effect of environmental factors on adult oviposition and egg hatch (1). The adult prefers a heavy, poorly drained soil for oviposition. Oviposition is low in dry, sandy soil and few eggs hatch. Insecticide tests will be more successful if the test site includes soil that is heavy, or high organic matter content, or poorly drained soil.

Site Selection:--Select an area with a history of southern corn rootworm damage, usually poorly drained soil, or soils with organic matter content of 2.0% or higher.

Procedures:--(Exhibit 9).

Statistical design - Randomized complete block or split plot for interaction studies.

Replication - Three or more replicates.

Plot size - Preferable minimum is 4 rows x 20 ft. (6.1 m).

Row spacing - Usually 36-inch (91.4 cm).

Application equipment - Any equipment that will accurately deliver as low as 5 lb. granules per acre with preference for granular row applicators.

Application method - Apply granules in a band over the row to cover the fruiting zone (generally 12-18 inches or 30.4-7 cm) and incorporate with a rotary hoe in top 1-2 inches (2.5-5 cm) of soil, except where excess plant growth does not permit incorporation.

Time of application (Insecticide) - Apply at pegging time (about 40 days post planting) to 30 days post-pegging.

Time of application (combination Insecticide-Nematicide) - Apply at planting (5) in a 12-14 inch (30.4-35.5 cm) band over the row or just prior to planting and incorporate with a rototiller to a depth of 2-4 inches (5-10 cm).

Controls - Untreated control plot and a standard insecticide treatment should be included for relative efficacy.

Evaluation:--(1,4).

Sample size - Select at random a minimum of 4 plants from each plot, remove all the pegs and pods, and count the number penetrated by the rootworm.

Interval between treatment and damage evaluation - 60 days after pegging application, or 30 to 45 days after post-pegging application, or approximately 20 to 40 days prior to harvest.

Calculation % damage - Use formula:

$$\% = \frac{\text{No. rootworm damaged pegs + pods}}{\text{Total No. pegs + pods}} \times 100$$

Yields - Harvest at least 2 rows of each plot, field cure on stack poles or artifically cure and weigh.

Effectiveness:--Candidate insecticides should compare favorably with those currently registered.

References

1. Campbell, W. V. , and D. A. Emery. 1967. Some environmental factors affecting feeding oviposition, and survival of the Southern corn rootworm. *J. Econ. Entomol.* 60:1675-8.

2. Sasser, J. N., K. R. Barker, and L. A. Nelson. 1975. Chemical soil treatments for nematode control on peanuts and soybeans. *Plant Dis. Rep.* 59:154-8.

3. Sell, R. A. 1916. Notes on the 12-spotted cucumber beetle. *J. Econ. Entomol.* 9:551-6.

4. Smith, J. C. 1971. Field evaluation of candidate insecticides for control of the Southern corn rootworm on peanuts in Virginia. *J. Econ. Entomol.* 64:280-1.

5. Smith, J. C. 1972. Tobacco thrips-nematode control on Virginia-type peanuts. *J. Econ. Entomol.* 65:1700-3.

Exhibit 9. Insecticide Test Method for Southern Corn Rootworm on Peanuts. W. V. Campbell, Department of Entomology, North Carolina State University, Raleigh.

Lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller)

The larva of the lesser cornstalk borer attack any part of the peanut plant that is in contact with the soil (1,3). Larvae may enter the main stem or lateral branches in contact with the soil and tunnel up and down the stems. After pegs and pods form, larvae attack them at and below the soil surface. Associated with the larvae at the point of entrance into the plant or fruit is a silken tube or webbing excreted by the larva.

Damage to seedling plant may cause stunting or death of the plant. Damage to seedling plants is most common on late planted peanust; however, the greater damage usually occurs after pegging (4).

Infestation and damage by the lesser cornstalk borer is more severe on dryland peanuts, in sandy soils, and during periods of drought.

Site Selection:--

Test site - Select an area with a history of drought and lesser cornstalk borer damage. Due to the sporadic nature of damage by the lesser cornstalk borer, field surveys for active infestations will provide the best test site.

Method of estimating infestation - Examine a minimum of 5 plants at each location (2). Include sufficient locations or stops in the field to provide the desired acreage for the intended experiment. At least 10% of the plants should be infested with cornstalk borers within the selected test site.

Procedures:--(1, 5).

Statistical design - Randomized complete block or split plot design.

Replications - Preferable minimum of three replicates.

Plot size - At least 4 row wide; however, the length of rows and number of rows will be dictated by the distribution patterns of lesser cornstalk borer.

Application method - Apply insecticide in a 16 to 20 inch (40.6 to 50.8 cm) band over the row.

> Basal directed spray: Use one flat-fan nozzle 80-degree even-flow on each side of the row. Tilt the nozzles at a 45 degree angle to the horizontal and adjust height to spray 8 to 10 inches (20.3 to 25.4 cm) on each side of the plant. The spray pattern should cover only the soil and lower leaves. It is important to use at least 20 gallons finished spray per acre (5).
>
> Application of granules: Apply granules when the foliage is dry in an 18 to 20 inch (4.5 to 50.8 cm) band over the row (1).

Incorporate granules with a rotary hoe if vine growth permits or irrigate within 48 hours (5). Any type of granular row applicator that will accurately deliver as little as 5 lbs granules per acre is satisfactory.

Controls - Include an untreated control and a standard insecticide treatment for comparative efficacy.

Evaluations:-- (1,5)

Sample size - Select 80 to 100 plants in each treatment and examine for live borers and fresh damage.

Interval between treatment and damage evaluation - Examine plants one week after treatment and at weekly intervals thereafter for residual insecticide efficacy data.

% control - May be calculated from pre-treatment and post-treatment counts compared with the untreated check.

Yields - The entire plot should be harvested, if feasible, and record yield and grades of cured peanuts.

Effectiveness:--Candidate insecticides should compare favorably with the insecticide(s) currently registered for the lesser cornstalk borer on peanuts.

References

1. French, J. C., and L. W. Morgan. 1972. The damage and control of the lesser cornstalk borer. *J. Am. Peanut Res. Educ. Assoc. Inc.* 4:41-2.

2. Hamman, P. J., C. E. Hoelscher, and J. W. Smith. Texas guide for controlling insects on peanuts. *Tex. Agric. Ext. Ser.* Leaf. L-704.

3. Leuck, D. B. 1966. Biology of the lesser cornstalk borer in south Georgia. *J. Econ. Entomol.* 59:797-801.

4. Leuck, D. B. 1967. Lesser cornstalk borer damage to peanut plants. *J. Econ. Entomol.* 60: 1549-51.

5. Smith, J. W., P. W. Jackson, R. L. Holloway, and C. E. Hoelscher. 1975. Evaluation of selected insecticides for control of the lesser cornstalk borer on Texas peanuts. *Tex. Agric. Exp. Stn. Prog. Rep.* PR-3303:16 p.

Granulate cutworm, *Feltia subterranea* (F.)

The moth oviposites singly or in small groups on the leaves at the periphery of the plant. The young larvae enter the soil at the base of the plant and feed on leaf litter or leaves touching the soil.

As larvae become more mature they will crawl up on the peanut plant at night and consume the foliage. During the day they remain hidden in the soil. Larvae will also tunnel into peanut pods. A heavy infestation of cutworms will result in complete defoliation of the crop and extensive pod loss.

Damaging infestations occur most frequently about mid July in Georgia and early August in North Carolina.

Site Selection:--Cutworm infestations are sporadic and unpredictable; therefore it will be necessary to scout for infested fields. They prefer sandy loam well-drained soils. Initiate examination of fields for damage about mid-season.

Procedures:--(2).

Statistical design - Randomized complete block experiment or split plot design.

Replication - Three or more replicates.

Plot size - 4 rows x 40 ft. (12.2 m).

Row spacing - Usually 36-inch (91.4 cm) rows.

Application method - Granules, baits, or sprays are applied in a band over the row to cover the foliage.

Time of application - Apply insecticides late in the afternoon.

Controls - Include an untreated control and a standard insecticide treatment for relative efficacy.

Evaluation:--(2)

Sample size - Select a minimum of 10 ft. (3.0 m) of row. Count all living and/or dead larvae from the center of one middle row to the center of a second middle row including the middle alley between the two rows.

Interval between treatment and evalution for efficacy - Evaluate insecticide performance 24 hours post treatment. Additional counts may be made at 24 hour intervals; however, interplot movement of cutworms may occur and mask the results.

Calculation of % control - Use Abbott's formula (1) or standard analysis of variance.

Yields - Harvest the entire plot for yield if this is feasible.

Effectiveness:--Candidate insecticides should compare favorably with those currently registered for cutworm control on peanuts.

References

1. Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. *J. Econ. Entomol.* 18:265-7.

2. Morgan, L. W., and J. C. French. 1971. Granulate cutworm control in peanuts in Georgia. *J. Econ. Entomol.* 64:937-9.

Burrowing bug, *Pangaeus bilineatus* (Say)

Burrowing bug adults migrate from weed hosts and invade peanut fields from mid-June through August in Texas (1). Females oviposit in the soil at the base of the peanut plant and adults and nymphs pierce the developing peanut kernels.

Feeding by the burrowing bug results in yellow to dark brown spots on the kernel which may be referred to as "pitting". Yields are generally not affected but peanuts with burrowing bug damage are downgraded if damage exceeds 2%. The grower is thus penalized for this damage by reducing the price paid for the affected load of peanuts.

Site Selection:--Select an area with a history of damage from the burrowing bug. Take soil samples and examine for burrowing bugs at regular intervals starting in mid-June. When bugs are first observed in soil samples, establish the experiment.

Procedures:--(2).

Statistical design - Randomized complete block or split plot design.

Replication - Four replicates or more.

Plot size - Minimum of 2 rows. Plot size will be governed by the distribution population of burrowing bugs.

Row spacing - Usually 36-inch (91.4 cm).

Application equipment - A granular row applicator

Application method - Apply insecticide granules in a 10 to 14 inch (25.4 to 35.5 cm) band over the row. If moisture is inadequate, irrigate the plots within 48 hours after treatment.

Time of application - Apply candidate insecticides within 7 days after adult burrowing bugs first invade the peanut field.

Controls - Include an untreated control and a standard insecticide treatment for relative efficacy.

Evaluation:-- (2).

Sample size - Collect soil from at least four 1-row ft. (30 cm) samples in each replicated plot and count the number of adults and nymphs of the burrowing bug.

Interval between treatment and evaluation - Collect soil samples at 10-14 day intervals after insecticide application for adult and nymphal counts. Collect a minimum of 50 pods at harvest and examine the kernels for burrowing bug damage. Express damaged kernels as % damage.

Yields - Obtain yield, grade, and dollar value/acre based on % burrowing bug damaged kernels.

Effectiveness:--Candidate insecticides should compare favorably with those insecticides currently registered for control of burrowing bug.

References

1. Smith, J. W., Jr., and J. T. Pitts. 1974. Pest status of *Pangaeus bilineatus* attacking peanuts in Texas. *J. Econ. Entomol.* 67:111-3.

2. Smith, J. W., Jr., T. H. Horlen, and J. T. Pitts. 1974. Field evaluation of insecticides for controlling burrowing bug in South Texas. *Tex. Agric. Exp. Stn. Prog. Rep.* PR-3268:5 p.

Tobacco thrips, *Frankliniella fusca* Hinds

Thrips injury to peanuts results in malformed leaves and stunted plants. Severe injury may delay flowering and fruiting several weeks and an 80%

loss in stand of very susceptible breeding lines occurred in North Carolina. Severe thrips damage does not occur every year in all peanut producing areas, in fact, the value of thrips control on yield increase has been questioned (1,4,5).

Granular systemic insecticides applied for thrips control may control a complex of insects (2). For this reason, in-furrow, at planting application of systemic insecticide should include the efficacy against the complex of insects.

The researcher should consider interaction effects of the soil-insecticide and the insecticide-peanut variety interaction as it affects insect control (Exhibit 10) and phytotoxicity.

Site Selection:--(Exhibit 10). Locate the test on the edge of a field with a weedy border or alternate host.

Procedures:--(4,5, Exhibit 10).

Statistical design - Randomized complete block or split plot design for interaction studies.

Soil type - It is desirable to include a variety of soil types.

Replications - 3 or more replicates.

Plot size - 1 row X 20 to 40 ft. (6.1 to 12.2 m) minimum.

Row spacing - Usually 36-inch (91.4 cm) rows.

Insecticide formulation - Granular or liquid systemic insecticides.

Application equipment - Gandy® 901-2 row applicator or equivalent or tractor-mounted granular row applicator or any technique that accurately and evenly distributes granules or liquids in a band.

Application method - Insecticide granules are applied in the seed furrow at planting time. Liquid systemic insecticides should be applied with injection equipment at planting time. Insecticides must be in the immediate zone of the germinating seed for efficient uptake or absorption of the systemic insecticide.

Control - Untreated control and one standard insecticide treatment should be included for relative efficacy.

Evaluation:--

Sample size (thrips)--Select from the center row(s) of each plot one terminal quadrifoliate leaf from 10 plants and record the number of adult and immature thrips (2, Exhibit 10).

Sample size (thrips damage) - Count the number of thrips-damaged leaves on one center row of each plot (Exhibit 10) or count the number of thrips-damaged leaves on 20 plants in the two center rows (4) or count the number of damaged leaflets on 10 plants from a sample of 12 leaflets per plant (5).

Interval between treatment and evaluation (Exhibit 10):--

Thrips counts: At weekly intervals or 30 to 45 days post planting.

Thrips damage: At weekly intervals or 45 to 60 days post planting.

Yield - Harvest the entire plot or at least two rows.

Effectiveness:--Candidate systemic soil-applied insecticides should compare favorably with insecticides currently registered for thrips control.

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Exhibit 10. Insecticide Test Method for Thrips Control on Peanuts. Campbell, W. V. North Carolina State University.

Potato leafhopper, *Empoasca fabae* Harris

See Exhibit 11.

References

Exhibit 11. Insecticide Test Method for Leafhopper Control on Peanuts. Campbell, W. V. North Carolina State University.

SUGARBEETS

Sugarbeets, *Beta vulgaris*, are subject to attack by a number of soil insects which reduce yields and affect the quality of sugarbeets. Among these insects are the sugarbeet root maggot, wireworms, root aphids, and various cutworms. Above ground portions of the plants are also attacked by aphids, leafhoppers, flea beetles, spinach carrion beetles, and larval stages of several lepidopterous insects. Some of the foliar feeding insects are controlled by soil treatment with systemic insecticides.

Sugarbeet root maggot is one of the major soil insect pests of sugarbeets. The test method for it is the only one reported here at this time, and is compiled from several sources. It is subject to revision and updating as needed.

Sugarbeet root maggot, *Tetanops myopaeformis* (Roder)

Researchers have used various modified test methods for evaluating chemical control of the sugarbeet root maggot. Test methods must of necessity be flexible because of the complexity of soil in relation to the problem. Species of insect, edaphic factors, distribution and other unpredictability of hidden populations relate to plot size and other variables. An attempt is made here to propose a composite test procedure with the necessary flexibility to cope with the variables encountered within an area and from area to area.

Site Selection:--The fields in which the test site is to be located should have been in sugarbeets the previous year or two, and have sufficient evidence of high potential maggot infestation. Lighter soils are frequently more apt to have heavy maggot populations than extremely heavy soils (1, 2, Exhibits 13, 14).

Crop and Plot Management:--A commercial susceptible variety of sugarbeet adapted to the area should be planted. Plot management techniques are usually the same as those employed for normal sugarbeet production (Exhibit 13).

Test Procedures:--The standard statistical or experimental designs are used (2, 3, Exhibits 13, 14). Usually a randomized complete block design is used but depending on the objectives of the experiment a split plot or other design might be better suited.

Generally 4 replications are adequate (2, 3, Exhibits 12, 13, 15), but frequently more are used (2, 3, Exhibits 12, 13, 14, 15).

Plot size may also vary from a single row 25 to 50 feet (7.5 to 15 meters) (1, and Exhibit II) to 2 or more rows wide by 25 to 100 feet (7.5 to 30 meters) (2, 3, Exhibits 12, 13, 14, 15).

Soil insecticides applied are primarily granular formulations. Adequate moisture will be necessary to activate the granules. Methods of granule application vary from a V-belt seeder (1, 2) to commercial planter-mounted granular applicators (Exhibits 12, 13, 14, 15). Granules are usually applied in a 4 to 7 inch (10.2 to 17.8 centimeter) band over-the-row at planting time (1, 2, Exhibits 12, 13, 14). Granules are sometimes applied as in-furrow treatments (Exhibits 13, 14, 15). In addition to or in place of planting-time treatments, postemergence treatments may be made by applying granules in a 4-6 inch (10.2 to 15.2 centimeter) band over the row when plants are in the 2-8 leaf stage, or no later than one week after first fly emergence (Exhibits 12, 13, 14, 15).

All insecticide granules should be at least lightly incorporated with either power incorporators, finger weeders, scratchers, a dragging chain or some similar device (Exhibits 12, 13, 14, 15).

Tests should contain untreated checks and at least one or more commercially acceptable or currently registered insecticides.

Natural infestations are relied upon for these tests.

Evaluations:--To evaluate the efficacy of soil insecticides for control of sugarbeet root maggots, technique criteria should include such things as stand counts, maggot counts, damage classification, yield and/or observations or measurements on phytotoxicity (1, 2, 3, Exhibits 12, 13, 14, 15).

1st count -- after plants have completely emerged to check for effects on germination and/or any phytotoxicity (Rating Scale 1-5 where 1 = no damage and 5 = severe damage).

2nd count -- immediately after mechanical thinning but before any stand reduction (plant loss) due to maggot injury (establishing base number for next count).

3rd count -- after major damage by maggots has occurred and no more stand loss is expected. A comparison of the 2nd and 3rd count gives reduction of stand due to maggots.

Maggot counts:--If taken, should be taken during mid-July in many states, by digging 4-10 beets per treatment per replication. Examine beet and soil within a 2-inch (5.1 centimeters) radius of beet to a depth of 8-10 inches (20.3-25.4 centimeters). Count and record as number of maggots per beet (1, 2, 3, Exhibits 12, 13, 15).

Damage evaluation:--(1, Exhibits 12, 13, 15) on roots (beets) can be made at the same time or on the same beets dug for maggot counts, or in lieu of maggot counts. The classes of damage rank from 1 to 5 and are defined as follows:

Class 1 - no damage

Class 2 - light damage; occasional small feeding scars

Class 3 - moderate damage; numerous small feeding scars but no tip damage

Class 4 - heavy damage; growing tip damage and/or heavy feeding scars

Class 5 - severe damage; tap root severed, severe feeding scars, dead or nearly dead or will die.

The root or beet damage classification is the most stable and most reliable criterion.

Yield data:--Consist of harvesting a minimum of a single row 20 to 100 feet (6 to 30 meters) in length per treatment per replication at normal harvest season for the area (1, 2, 3, Exhibits 12, 13, 14, 15). Size of harvest sample may vary depending on equipment available. Although size of plot may vary, data recorded should include number of beets per acre (hectare), tons (tonnes) of beets per acre (hectare), and/or pounds (kilograms) of sugar per acre (hectare). If desired, percent sucrose and purity can be determined from the same samples.

Effectiveness:--In all categories of evaluations, experimental treatments are compared with standard treatments and untreated controls. Percent control is based on treatments versus untreated checks. The data are analyzed according to standard analysis of variance procedures. Differences among treatment means are determined by numerous methods such as LSD, Duncan's New Multiple Range Test, etc. (1, 2, 3, Exhibits 12, 13, 14, 15).

References

1. Peay, W. E., C. E. Stanger, and A. A. Swenson. 1968. Preliminary evaluation of soil insecticides for sugarbeet root maggot control. *J. Econ. Entomol.* 61(1):19-21.

2. Peay, W. E., G. W. Beards, and A. A. Swenson. 1969. Field evaluations of soil and foliar insecticides for control of the sugarbeet root maggot. *J. Econ. Entomol.* 62(5): 1083-8.

3. Yun, Y. M. 1972. Additional criterion for evaluating insecticide treatments for control of sugarbeet root maggot larvae. *J. Am. Sugar Beet Technol.* 17(1):49-52.

Exhibit 12. Procedures for Testing Insecticides Against Sugarbeet Root Maggot. C. C. Blickenstaff. USDA-ARS, Kimberly, Idaho.

Exhibit 13. Test Method for Determining Field Efficacy of Soil Insecticides for Control of Sugarbeet Root Maggots. C. C. Burkhardt. University of Wyoming, Laramie.

Exhibit 14. Methods to Evaluate Insecticides for Sugarbeet Root Maggot Control. R. D. Frye. North Dakota State University, Fargo.

Exhibit 15. Methods of Insecticide Testing for Sugarbeet Root Maggot Control. Y. Mok Yun. Great Western Sugar Company, Longmont, Colorado.

TOBACCO

Tobacco is attacked by a complex of soil inhabiting insects and leaf feeding pests in the plant bed, newly set transplants, and established plants in the field until leaf harvest.

The major soil insects are primarily a problem in the plant bed, newly set transplants, and young field plants. This soil insect complex includes larvae of the tobacco wireworm *Conoderus vespertinus* (F.), southern potato wireworm *Conoderus falli* Lane, green June beetle *Cotinus nitida* L., dark-sided cutworm *Euxoa messoria* (Harris), and the mole cricket *Scapteriscus acletus* Rehn and Hebard.

Foliage feeding pests such as the tobacco flea beetle *Epitrix hirtipennis* (Melsheimer), tobacco budworm*Heliothis virescens* (F.), and the tobacco hornworm *Manduca sexta* (L.) may be controlled by soil-applied systemic insecticides.

The test methods for control of selected insects are those generally accepted by the tobacco researchers but the test methods are intended to be flexible and will be changed or updated as more effective methods are developed.

Tobacco wireworm,*Conoderus vespertinus* (F.) and Southern potato wireworm, *Conoderus falli* Lane

Wireworms attack tobacco overwinter as larvae and therefore cause the greatest damage to transplants and young field plants. Wireworm populations are variable even in areas with a history of wireworm damage; therefore, prior knowledge of the wireworm population is essential to the success of the insecticide test.

Site Selection:--Survey each spring to locate field with heavy wireworm populations perferably in the range of 100-300 thousand larvae/acre (2).

Procedures:--

Statistical design - Randomized complete block or split plot design.

Replication - Three or more replicates.

Plot size - 4 rows wide and 36 ft. (11 meters) long with 8 ft. (2.4 meters) alleys between blocks (3) to 62-1/2 ft. (19.1 meters) long with 20 ft. (6.1 meters) alleys between blocks (2).

Row spacing - Usually 48-inch (121.9 cm) rows.

Application method - Broadcast granules by hand (3) or by tractor mounted granular applicator (1) that will accurately and evenly apply granules. Granules should be broadcast and immediately disked into the soil one to four weeks prior to transplanting (2) . Fumigants were injected on 12-inch (30.4 cm) centers to a depth of 6 to 8 inches and sealed in with a drag. Liquids are applied with a sprinkling can and rotary tilled to a depth of 4 to 5 inches (9.1 to 12.7 cm) (3); or liquids are applied broadcast with a tractor-mounted sprayer.

Control - Untreated control and a standard insecticide treatment should be included for comparative efficacy.

Evaluation:--

Sample size - Examine 40 plants (2) to 192 plants (3) taken from the middle two rows. Split the stems lengthwise with a scalpel and record wireworm damaged plants.

Interval between treatment and evaluation - Collect plants for damage evaluation 10 to 14 days after transplanting (2) or record plants killed by wireworms at 7 day intervals after transplanting and examine the remaining plants for wireworm damage to the roots and stems within approximately 4 weeks after transplanting (3).

Analysis of data - Data are subjected to ANOVA and Duncan's multiple range test (3) or percentages are transformed to angles and then analyzed statistically using Duncan's multiple range test (2).

Effectiveness:--Candidate insecticides should compare favorably with insecticides currently registered for wireworm control. Phytotoxicity ratings are important expecially for cigar-wrapper tobacco (3).

References

1. Allen, Norman. 1973. Experiments on the interval between treatment for the control of wireworms and transplanting flue-cured tobacco. *Tob. Sci.* 17:93-5.

2. Mistric, W. J., and F. D. Smith. 1969. Chemical control of tobacco and southern potato wireworms on flue-cured tobacco during 1964-68. *J. Econ. Entomol.* 62:712-15. (See modification following references.)

3. Tappan, W. B. 1966. Insecticides tested for wireworm control on cigar-wrapper tobacco. *J. Econ. Entomol.* 59:1161-3.

Modification of Mistric and Smith (1969)

Site Selection:--Take 5 core soil samples of 4 inch (10.1 cm) diameter and 6 inches (15.2 cm) deep over an area of 0.1 acre or take 50 core samples over an area of 1 acre. Slowly screen each soil sample through a ¼ to ¼ inch (0.6 x 0.6 cm) hardware cloth and recover and count larvae as they fall. One larva/5 core samples = 100,000/acre. Select fields with heavy larvae population; that is, 100,000 to 300,000/acre.

Interval between treatment and transplanting:--One to four weeks

Interval between transplanting and sampling for wireworm damage:--10 to 14 days.

Size of sample for damage evaluation:--40 plant sample.

Dark-sided Cutworm, *Euxoa messoria* (Harris)

The dark-sided cutworm overwinters in the egg stage and young larvae hatch in the spring and feed on the rye cover crop. When tobacco is transplanted in the spring, cutworm larvae (after the 3rd instar) attack the leaves, growing points, and stems. Replanting may be necessary when cutworm populations are high (1).

Site Selection:--Select fields with a range of soil types. Preferably fields selected should have a history of cutworm damage and not treated with insecticides for several years (1).

Procedures:--(1, 2, 3).

Statistical design - Randomized complete block or split plot design.

Plot size - 4 rows or more with a minimum of 40 plants in each row.

Plant spacing - Transplant tobacco plants on 24 inch (61 cm) centers.

Row Spacing - Minimum of 42-inch (106 cm) row width.

Barrier strip - Aluminum barrier strips 8 inches high (20.3 cm) are embedded in the soil to a depth of 3 inches (7.6 cm) completely encircling the untreated control plot to prevent cutworm larvae from migrating to adjacent plots.

Replication - A minimum of two replicates but preferably more.

Method of insecticide application - Apply broadcast over the rye cover crop, or over the soil surface, or over the plants. Sprays are applied with a knapsack sprayer or tractor powered sprayer that will deliver 25 gal spray/acre. Baits may be hand distributed. Insecticides should be incorporated to a depth of 1 inch (2.5 cm) immediately after treatment.

Control - Untreated control and a standard insecticide treatment should be included for comparative efficacy.

Evaluation :--(1, 2, 3)

Sample size - Examine all plants in the center row(s) for cutworm damage and for larval populations.

Interval between transplanting and evaluation - Counts should be made at weekly intervals starting one week after transplanting and continue until larvae complete their feeding and pupate.

Percent damage - Record damage as % damage based on the total number of plants examined in each sampled row.

Tobacco quality evaluation - Leaf samples from 5 pullings (leaf harvests) per plot are dried and ground to pass through a 2 mm sieve. Samples are then freeze dried and analyzed for % total alkaloids (4) and reducing sugars (5).

Analysis of data - Data should be subjected to an analysis of variance and Duncan's multiple range test.

Effectiveness:--Candidate insecticides should compare favorably with insecticides currently registered for cutworm on tobacco. Phytotoxicity rating, insecticide residue, and smoke taste evaluations are usually required for registration of insecticides.

References

1. Cheng, H. H. 1971. Field studies on the chemical control of the dark-sided cutworm (Lepidoptera: Noctuidae) on tobacco in Ontario, with particular reference to Dursban. *Can. Entomol.* 103:649-53.
2. Cheng, H. H. 1973a. Laboratory and field tests with *Bacillus thuringiensis* against the dark-sided cutworm, *Euxoa messoria.* (Lepidoptera: Noctuidae) on tobacco. *Can. Entomol.* 105:941-5.
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Green June Beetle, *Cotinus nitida* (L.)

Adults are attracted to manure or other organically rich soil for oviposition in late summer. Larvae feed on organic matter in the soil or on the soil surface at night. Feeding and tunneling in the soil continues until cool weather. Larvae overwinter as mature 3rd instar and become active when the temperature rises (generally above 55°F) in the spring.

Larvae damage tobacco in the plant bed which is established in the winter. Larvae do not feed directly on the tobacco seedlings but cause damage by uprooting plants in search for food near the soil surface and on the soil surface (1, 4). Large numbers of larvae also completely pulverize the soil and cause excessive moisture stress on the young plants.

Site Selection:--Survey for an area with evidence of green June beetle larvae. Damage may best be detected in late September and October. The application of manure to a rich, moist snady loam soil may be useful in attracting ovipositing adults to the test site. Larvae may also be easily reared (3) for artificial infestation or to supplement natural infestation.

Procedures:--(1, 4).

Statistical design - Randomized complete block, Latin square or split plot design.

Replication - 4 or more replicates.

Plot size - 1 sq. yd (sq. meter) or larger. Separate plots by 6-inch to 8-inch (15.2 to 20.3 cm) boards placed in ground 2-inches to 6-inches (5.1 to 15.2 cm) deep to prevent larval migration.

Application method - Apply granules and baits by hand or with granular or fertilizer applicators. Liquids are applied with knapsack sprayer and drenches with a sprinkling can. Mix insecticides into the top 2 inches (5.1 cm) of soil immediately when insecticides are applied prior to planting. Cover plots with tobacco cloth to exclude birds and animals.

Application time - Apply when the larvae are active in the fall or just prior to seeding the plant bed or after seedling plants are established.

Control - Include an untreated control and a standard insecticide treatment for comparative efficacy.

Evaluation:--(1, 2, 4).

Sample size - Sample the whole plot. Count dead larvae on soil surface. Moribund larvae are counted as dead since they do not re-enter the soil.

Interval between treatment and evaluation - Approximately 6 weeks after seed germination when plots are treated just prior to seeding. If treatments are applied in the spring when larvae are active, sample for dead larvae 2 days after treatment and continue to record mortality for one week. At the end of two weeks excavate the plot to a depth of 6 to 12 inches (15.2 to 30.4 cm) and count all living and/or dead larvae.

Analysis of data - Subject data to an analysis of variance and Duncan's multiple range test.

Effectiveness:--Candidate insecticides should compare favorably with those currently registered for green June beetle control. Phytotoxicity and tobacco quality determinations should be made consistent with accepted standards.

References

1. Dominick, C. B. 1950. Organic insecticides for the control of green June Beetle larvae. *J. Econ. Entomol.* 43:295-8.

2. Dominick, C. B. 1955. Further experiments with insecticides for control of green June beetle larvae. *J. Econ. Entomol.* 48:621-2.

3. Howe, W. L., and W. V. Campbell. 1953. A simple method for rearing green June beetle larvae. *U. S. Bur. Entomol. Plant Juar.* ET-307.

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Tobacco flea beetle, *Epitrix hirtipennis* (Melsheimer)

Newly set tobacco plants are especially vulnerable to attack by overwintering adults of the tobacco flea beetle. Flea beetles are considered the most damaging pest of burley tobacco in Kentucky (2). High populations of the second generation may severely damage leaves of the lower third of the mature plant. In addition larvae feed upon tobacco roots and may severely damage newly set plants (1).

Site Selection:--Locate test near flea beetle overwintering sites near a woodlot or an old field (Exhibit 16).

Procedures:--

Statistical design - Randomized complete block.

Replications - 3 or more replicates.

Plot size - 6 rows wide and 24 ft. (7.3 m) long with an uncultivated border strip 8 ft. wide (2.4 m) separating plots on all sides (1).

or plots 4 rows X 62½ ft. (19.0 m) with blocks separated by 20 ft. (6.1 m) alleys (3) or 4 to 8 rows wide X 20 to 30 ft. (6.1 m to 9.1 m) long (2).

Row spacing - 49-inch (120 cm) rows (Exhibit 16).

Plant spacing - Plants spaced 20 inches (50.8 cm) on center (Exhibit 16).

Application equipment - Apply granules with a hand applicator or cyclone seeder. Sprays are applied with hand or tractor-mounted sprayer.

Application method - Apply granules broadcast or in-furrow or apply granules and sprays in a 12 inch (30.4 cm) band.

Pretransplant treatments are disked immediately into the soil to a depth of ca. 3 to 4 inches (7.6 to 10.1 cm) 0 to 4 days prior to transplanting.

Post transplant treatments are applied on both sides of the row just ahead of the final cultivation.

Control - Untreated control and at least one standard insecticide treatment (Exhibit 16).

Evaluation:--

Sample size - Select 5 plants in each of the two middle rows and examine for live flea beetles. Count the number of feeding punctures on damaged leaves from each of 6 randomly selected plants in the two center rows on newly set tobacco or count all beetles on 6 randomly selected plants during late season. Count the number of adult flea beetles and number of flea beetle holes/ 20 plants at intervals during the season.

Interval between treatment and evaluation - The most damaged leaf from each of 6 randomly selected plants in the two center rows of each plot are removed 14 days after transplanting to count flea beetle punctures. Late season evaluation is made by beetle population counts at weekly intervals beginning 4 weeks after transplanting.

Analysis of data - Subject data to an analysis of variance test, Duncan's Multiple Range test, or transform data to square roots and analyze.

Effectiveness:--Candidate insecticides should compare favorably with those currently registered for control of flea beetles on tobacco. Phytotoxicity and tobacco quality ratings are necessary for registration of a new soil insecticide.

References

1. Dominick, C. B. 1967. Systemic insecticides applied to the soil for control of the tobacco flea beetle on tobacco. *J. Econ. Entomol.* 60:1468-9.

2. Jones, G. A. and Richard Thurston. 1973. Seasonal control of insects on burley tobacco with soil-applied insecticides. *Tob. Sci.* 17:102-4.

3. Mistric, W. J. and F. D. Smith. 1973. Carbofuran and other systemic insecticides for control of insects on flue-cured tobacco. *J. Econ. Entomol.* 66: 480-4.

Exhibit 16. Insecticide Test Method for Flea Beetle on Tobacco. P. J. Semtner. Virginia Polytechnic Institute and State University, Southern Piedmont Research and Education Center, Blackstone, Virginia.

VEGETABLE CROPS

Vegetable crops are subject to attack by numerous soil insects which lower crop quality, reduce yields, or result in crop failure. Among these soil insects are the wireworm complex, white grubs, various species of root maggots, cutworms, and root weevils.

The test methods for control of selected insects are prepared from those methods generally employed by past and present researchers around the country. Though individual test methods may vary with the soil insects and the crops of various areas of the country the test methods proposed are composite procedures with sufficient flexibility to meet the variables. These test methods are subject to revision as needed.

Cabbage maggot, *Hylemya brassicae* Bouche

The test crops include: cabbage, *Brassica oleracea* L. (Capitata group) (5); cauliflower, *Brassica oleracea* L. (Botrylis group); Broccoli, *Brassica oleracea* (Italica group); and brussels sprouts, *Brassica oleracea* L. (Gemmifera group).

Site Selection:--Conduct test in an area where crucifers have been grown for several years and a root maggot infestation is present.

Plot Management:--Transplants may be set at an in-row spacing of 12-21 inches (30-50 cm) with rows spaced at 18-36 inches (0.5-0.9m).

Plant seed at a depth of ca 1/2 inch (12 mm) or less.

Procedures:--

Use a randomized complete block, split plot, or other experimental design.

Use four or more replications.

Use one or more rows 10 to 50 feet (3-15m) or longer per plot (3,4).

Plant one or more border rows on each side of the experimental block. Treat just prior to planting, at planting, just after planting (pre- or post emergence) for direct seeded crops, or treat seed. Transplants can be treated prior to planting (root dip or broadcast treatment), at planting (transplant water or spray drench) or just after planting (spray drench). Additional sprays directed at the base of the plant and soil surface may be applied as succeeding generations of root maggots emerge during the growing season (3,4).

Effective time of treatment can be determined by fly-emergence peaks from baited cone screen traps, wood stakes treated with a sticky material as Tanglefoot®, and/or by use of day degree accumulations (1).

Apply granules with a cone seeder, V-belt seeder, Planet Jr.®, or other calibrated hand equipment or use hoppers with a metering device or broadcast applicators (2,3,4).

Apply dusts with a calibrated hand or power duster.

Apply liquid treatments with calibrated hand or power equipment (2,3,4). Transplant water treatments can be applied with the nutrient solution by means of a commercial applicator to each plant or with a measured amount of solution applied by hand.

Treat seed by slurry, use of powders or dusts and a sticker, planter box treatment or other method as infusion.

Untreated controls shall be used to determine the severity of maggot infestation and to provide a basis for comparison of the treatments.

A standard insecticide treatment should be included, whenever possible, for comparison of the treatments.

Evaluations:--(2, 3)

Determine percent infestation by counting maggot damaged roots in a given sample size. Sample size may vary from 10 to 25 or more roots per replicate depending on the infestation.

Damage ratings can be utilized to determine efficacy as follows: 1-no feeding scars; 2-minor damage and tunneling moderate to extensive. The percent of roots in each damage class is then determined.

A similar system is as follows: 1-clean, no discernible maggot injury; 2-slight, with a few minor surface injuries, or injury confined to the tap root, which is normally removed; 3-moderate, with 2 maggot tunnels; 4-heavy, with 3 or more maggot tunnels. A control rating is obtained by multiplying the numbers of clean roots by a factor of 4; those with slight injury by 0. With 25 roots examined per plot, the highest control rating possible would be 100 (3).

The actual number of root maggot tunnels or infested plants can be counted for a sample of 10 to 25 or more roots per replicate. The means are compared (4).

Yield data should be taken whenever possible and expressed in tons per acre (Kg./ha.) or pounds (Kg) per given number of heads.

Evaluations may be conducted after each generation of root maggots to determine the term of effective control provided by a given material or at harvest to determine effective control on a seasonal basis (3,4).

Observe seedling plants for phytotoxic effects as off-color foliage, delayed emergence, loss of stand related to the insecticide, etc. Conduct plant stand counts (3).

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis is used, so state.

References

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3. Howitt, A. J., and S. G. Cole. 1962. Chemical control of *Hylemya brassicae* in the Pacific Northwest. *J. Econ. Entomol.* 55:33-8.

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Cabbage Maggot, *Hylemya brassicae* (Bouche)

The test crop is the radish *(Raphanus sativus* L.*)*, synonym - Rabano.

Site Selection:--Conduct test in an area where cruciferous crops have been grown previously and a cabbage maggot infestation is present. The cabbage maggot includes radish, rutabaga, turnip, cabbage, cauliflower, broccoli and brussels sprouts among its host crops.

Plot Management:--Plant rows at 15 to 36 inches apart (0.375-0.9m) in other plot areas (1,2,3,4,6,8).

Procedures:--

Use a randomized complete block, split plot, or other experimental design.

Use four or more replications per treatment.

Use single row treatments 10 to 50 feet long (3-15m).

Plant one or more border rows on each side of plot block.

Apply granules with a cone seeder, V-belt seeder, Planet Jr.®, or other calibrated hand equipment or use hoppers with a metering device or broadcast applicators (1,2,3,4,5,6,8).

Apply dusts with a calibrated hand or power duster. Apply liquid treatments with calibrated hand or power equipment.

Treat seed by slurry, use of powders or dusts and a sticker, planter box treatment or other method as infusion.

Applications should be made whenever a crop of radish is planted as there are at least three generations of cabbage maggot per growing season in Northern United States production areas.

Untreated controls shall be used to determine the severity of maggot infestation and to provide a basis for comparison of the treatments.

Evaluations:--(1,2,3,4,6,8)

Determine percent infestation by counting maggot damaged radishes in a given sample size. Sample size may vary from 25 to 100 or more per replicate depending on the maggot population.

The number of maggot tunnels on a given number of radishes, for example, 25 per replicate are counted and recorded.

Radish is a short period crop from planting to harvest. Maggot damage evaluations should be conducted at harvest.

Observe seedling plants for phytotoxic effects as stunting, off-color foliage, delayed emergency, loss of stand related to the insecticide rather than the insect, etc. (3, 8).

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis procedure is used, so state.

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Cabbage Maggot, *Hylemya brassicae* (Bouche), Turnip Maggot, *Hylemya floralis* (Fall.)

The test crops include: rutabaga (*Brassica napus* L.) (9) (synonyms-Swede, Swedish turnip, turnip, rooted cabbage, Laurentian turnip, Russian turnip), and Turnip (*Brassica campestris* L.) (synonyms-Rappina, Rappone, Rapa, Rapini).

Site Selection:--Conduct test in an area where cruciferous crops have been grown previously and a root maggot infestation is present.

Plot Management:--A 36 inch (0.9m) spacing between rows and a seeding rate of 12 to 20 seeds per foot is generally used. After plants are growing plots should be thinned to 1 plant every 4 to 6 inches

(10-15 cm).

Procedures:--(1,2,3,5,6,7,8,10, Exhibit 17).

Use a randomized complete block, split plot, or other experimental design.

Use four or more replications.

Single row treatments 10' (3 m) or more long.

Plant one or more border rows on each side of plot block.

Treat just prior to planting, at planting, just after planting, or treat seed. Additional treatments directed at the base of the plant and soil surface may be applied as succeeding generations of root maggots emerge during the growing season.

Effective time of treatment can be determined by fly-emergence peaks from baited cone screen traps, wood stakes treated with Tanglefoot® and/or by use of day degree accumulations (4).

Apply granules with a cone seeder, V-belt seeder, Planet Jr.®, or other calibrated hand equipment or use hoppers with a metering device or broadcast applicators.

Apply dusts with a calibrated hand or power duster.

Apply liquid treatments with calibrated hand or power equipment.

Treat seed by an accepted method as slurry, use of powders or dusts and a sticker, planter box treatment or other method as infusion.

Untreated controls shall be used to determine the severity of maggot infestation and to provide a basis for comparison of the treatments.

A standard insecticide treatment should be included, whenever possible, for comparison of the treatments.

Evaluations:--(1,2,3,5,7,8,10).

Determine percent infestation by counting maggot damaged roots in a given sample size. Sample size may vary from 10 to 25 or more roots per replicate depending on the infestation.

Damage ratings can be utilized to determine efficacy as follows: 1-no feeding scars. 2-minor damage; 3-surface damage moderate; 4-5-surface damage and tunneling moderate to extensive. The percent of roots in each damage class is then determined.

A similar system is as follows: 1-clean, no discernible maggot injury; 2-slight, with a few minor surface injuries, or injury confined to the tap root which is normally removed; 3-moderate, with 1-2 maggot tunnels; 4-heavy, with 3 or more maggot tunnels. A control rating is obtained by multiplying the numbers of clean roots by a factor of 4; those with slight injury by 2; moderate by 1; and those with heavy injury by 0. With 25 roots examined per plot, the highest control rating possible would be 100 (5, 7, Exhibit 17).

The actual number of root maggot tunnels per root can be counted for a sample of 10 to 25 or more roots and the means compared as in 3.5.

Evaluations may be conducted after each generation of root maggots to determine term of effective control provided by a given material or at harvest to determine effective control on a seasonal basis (1,2,3, 5,7,8,10, Exhibit 17).

Observe seedling plants for phytotoxicity symptoms, off-color foliage, delayed emergence, loss of stand related to the insecticide, etc. Conduct plant stand counts.

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis procedure is used, so state.

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Exhibit 17. Method of Testing Chemicals for Efficacy Against the Cabbage Maggot, *Hylemya brassicae* (Bouche). H. H. Crowell. Dept. of Entomology, Oregon State University, Corvallis.

Onion maggot *(Hylemya antiqua* Meigen*)*

The test crop is the onion, *Allium cepa* L. (2), synonym - cebolla.

Site Selection:--Conduct test in an area where onions have been grown for several years and an onion maggot infestation is present. The onion maggot is specific to onion as its agricultural host crop is favored by cool, wet spring seasons.

Plot Management:--Plant transplants 4-6 inches (10-15 cm) apart in the row or seed at a rate to yield 6 to 12 plants per foot (30 cm) of row.

Procedures:--(1, 3)

Use a randomized complete block, split plot, or other experimental design.

Use four or more replications.

Use single row treatments 10 to 30 feet (3 to 9m) or more long.

Plant one or more border rows on each side of plantblock.

Treatments should be applied at or near planting time during the overwintering brood onion maggot emergence period.

Apply granules with a cone seeder, V-belt seeder, Planet, Jr.®, or other calibrated hand equipment or use hoppers with a metering device or broadcast applicators.

Apply dusts with a calibrated hand or power duster.

Apply liquid treatments with calibrated hand or power equipment.

Treat seed by slurry, use of powder or dusts and a sticker, planter treatment or other method as infusion.

Untreated controls shall be used to determine the severity of maggot infestation and to provide a basis for comparison of the treatments.

A standard insecticide treatment should be included, whenever possible, for comparison of the treatments.

Evaluations:--

Determine percent damage by counting and removing maggot injured plants until plant mortality ceases and computing from total plant stand for each treatment.

Damage ratings can be used to assess the stand: 1-even stand to 5-extensive damage.

Direct counts of maggot injured plants per given length of row can be utilized (3).

Yield data can be expressed as bags per acre (2) or as cwt per acre.

Evaluate weekly or as needed while damaged plants continue to appear (3).

A stand rating would be conducted when overwintering brood maggot injury terminated.

Early plant stand observations for phytotoxicity and counts are made to determine any delayed germination with final stand counts made when the first maggot injury appears.

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis procedure is used, so state.

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Seed corn maggot, *Hylemya platura*(Meigen)

The test crops include: snap bean, *Phaseolus vulgaris* L. (6); lima bean, *Phaseolus lunatus* L.; dry beans, *Phaseolus vulgaris* L.; sweet corn, *Zea mays* L.; English or garden pea, *Pisum sativum* L.; and the curcubits, cucumber, *Cucumis sativus* L.; pumpkin and summer squash, *Cucurbito pepo* L.; winter squash, *Cucurbita moschata*; and Duch ex poir, *C. maxima* Duch.

Site Selection:--The seed corn maggot has a rather broad host range of vegetable crops and prefers areas of high humus (7). Cool wet seasons that slow seed germination favor seed corn maggot damage.

Plot Management:--

Infestations can be enhanced by baiting along the rows with meat and bone meal at the rate of ca. 0.5 lb. (0.225 Kg) per 15 feet (4.5m) of row (2,3,7).

One hundred or more seeds should be planted in rows 15 feet long (4.5m) or longer (1,2,3,4,7).

Procedures:--(1,2,3,4,5,7).

Use a randomized complete block, split plot, or other experimental design.

Use four or more replications.

Single row treatments are sufficient.

Plant one or more border rows on each side of the plot block.

Treatments should be applied at or near planting time during the overwintering generation seed corn maggot emergence period.

Effective time of treatment can be determined by timing planting with fly-emergence peaks from baited cone screen traps (4) or wood stakes treated with Tanglefoot®, and/or by use of day degree accumulations (8).

Apply granules with a cone seeder, V-belt seeder, Planet, Jr.®, or other calibrated hand equipment or use hoppers with a metering device or broadcast applicators.

Apply dusts with a calibrated hand or power duster.

Apply liquid treatments with calibrated hand or power equipment.

Treat seed by slurry, use of powders or dusts and a sticker, planter box treatment or other method as infusion.

Untreated controls shall be used to determine the severity of maggot infestation and to provide a basis for comparison of the treatments.

A standard insecticides treatment should be included, whenever possible, for comparison of the treatments.

Evaluations:--

Determine percent damage by counting maggot injured plants or healthy plants and computing from total plant stand for each treatment (2,3,4,7).

Damage ratings can be used to assess the stand: 0-no damage to 10-total destruction (1).

Direct counts of maggot injured plants or healthy plants per given length of row can be utilized (7,9).

Or, dig up and examine a minimum of 10 plants or seeds per replicate (1,9).

Evaluate when second true leaves have fully expanded (2), or 2 to 4 weeks after planting (2,3,4,7,9).

Phytotoxicity observations should be made at seedling emergence and thereafter. Stand reduction, delayed emergence, distortion, or off-color foliage due to chemical injury should be recorded.

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis procedure is used, so state.

References

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Tobacco wireworm, *Conoderus vespertinus* (Falr.) and Southern potato wireworm, *Conoderus falli* Lane

The test crop is the sweet potato, *Ipomoea batatas* (L.) Lam. (5).

Site Selection:--

Conduct test in an area known to have a wireworm infestation (1).

If necessary, sample soil to determine wireworm species. At least 4 soil samples of 6 inches X 6 inches X 6 inches (15 cm X 15 cm X 15 cm) each would be needed; where populations are sparse, enlarge samples to 12 inches X 12 inches X 6 inches (30 cm X 30 cm X 15 cm) or use the 6 X 6 X 6 inch sample size or all samples (2).

Allowing plots to grow up in native grasses and weeds is conducive to high populations of *C. falli* Lane (2).

Procedures:--(1,2,3,4)

Use a randomized complete block or split plot design.

Use three or more replications.

Use 3 or more rows 25 feet (7.5m) long or longer per treatment.

Use 1 or more center rows of each treatment for results.

Applications made early in the oviposition period are most effective in the Southeastern U. S. (2).

Apply granules or baits with a cyclone seeder, modified Mitchell-Ventura® planter, or other calibrated hand equipment or hoppers with a metering device or broadcast applicator. Disc into upper 4-5 inches of soil for pre-plant incorporation. Mid-season granular treatments remain on soil surface.

Apply other formulations with calibrated hand or power equipment.

Applications are made prior to planting and midseason as over the foliage treatments with granules or baits for soil treatment.

Untreated controls shall be used to provide a basis for comparison of the treatments.

A standard insecticide treatment should be included, whenever possible, for comparison of the treatments.

Evaluations:--

Determine injury by randomly selecting a sample of 25 or more roots per replicate and counting the number of wireworm injured tubers and the total number of wireworm scars.

A damage index can be utilized whereby wireworm damage is evaluated by digging the 2 center rows in each plot, from which sweet potatoes ar-selected at random for scoring. One hundred samples are taken per treatment for each experiment. Damage classes are: 0=no damage; 1=up to 5 holes; 2= 6-10 holes; and 3= 11 or more holes per sweet potato. The damage figure averages constitute the "damage index".

"Percent damage control" is arrived at by the following formula: for treated sweet potatoes let A = the damage index and B = the percent sweet potatoes damaged; for untreated control sweet potatoes let X = the damage index and Y = the percent sweet potatoes damaged; then 100 - (AB/XY x 100) = percent damage control, a factor which reflects the effectiveness of the insecticide by comparing wireworm damage to sweet potatoes from treated plots with potatoes from untreated plots (1).

Sweet potatoes are a long term crop with a five to six month period from planting to harvest in the Southeastern U. S. (1). Damage has not been observed on newly set plants but appears a month or two later when roots begin to enlarge. Therefore, treatments are evaluated for effectiveness at harvest.

Observe plants for phytotoxic injury as stunting, off-color foliage, etc. after planting, for pre-plant treatments, and after the mid-season over the foliage treatments.

Analyze the results using conventional analysis of variance and express significance at the 95% confidence level. If another type of analysis procedure is used, so state.

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Conoderus, *Limonius*, and *Ctenicera* spp.

Some of the species would be: Southern potato wireworm, *Conoderus falli* Lane; Pacific Coast Wireworm, *Limonius canus* Le Conte; Great Basin wireworm, *Ctenicera pruinina* (Horn).

The test crop is the potato, *Solanum tuberosum* L. (2) (synonyms - Irish potato, white potato).

Site Selection:--Southern potato wireworms are favored by areas that have grown up to grasses before crops are planted or are cover cropped to produce a high level of organic matter (11).

Onsager developed a method of sampling to detect economic infestations of *Limonius* spp. based upon the relationship among the number of 1/4 ft^2. (7.5cm^2) subsamples, number of wireworms and upper confidence limit of population density for *Limonius* spp. His sampling data followed a Poisson distribution. The method was developed to detect and estimate economic populations (0.1 per ft^2). Refer to References (3, 9) for the details of the sampling method.

Procedures:--

Use a randomized complete block, split plot or other experimental design.

Use two or more replications for large acreage tests (10) and four or more replications for smaller plots.

Use four or more rows per treatment with a row length of 25 feet (7.5m) or more (4,6,7,9,11).

Use 2 or mroe center rows for small plot results (4, 11) or harvest a given number of hills for examination (4,6,11).

Apply granules or baits with a cyclone seeder, Planet, Jr.® or other calibrated hand equipment or hoppers with a metering device or broadcast applicator (1, 4, 6, 7, 9, 11).

Apply other formulations with calibrated hand or power equipment (1, 6).

Treat seed pieces by slurry, use of powders or dusts and a sticker, planter box treatment, dipping, or other stated method.

Applications are made prior to planting, at planting, or post planting (pre- or post-emergence) (4,6,7,9,11).

Untreated controls shall be used to provide a basis for comparison of the treatments.

A standard insecticide treatment should be included whenever possible, for comparison of the treatments.

Evaluations:--

Determine injury by randomly selecting at least 100 tubers per replicate and counting the numbers of wireworm injured tubers (4, 6, 9, 11).

Harvest and examine all tubers in at least 25 feet (7.5m) of row per plot for wireworm injury (7).

Determine yield at harvest (4,9).

Observe plants for phytotoxic injury as stunting, off-color foliage, delayed emergence, etc. from the time plants emerge.

Results may be analyzed by subjecting percentage injury and damage by wireworms on the basis of tuber numbers and tuber weights to correlation and linear regression analyses to determine the relationship between numerical percentages and weight percentages. This analysis indicated that percentage ratings based on tuber counts or weights were directly comparable for *Limonius canus* LeConte injury (5,8).

Results may be analyzed using conventional analysis of variance and express significance at the 95% confidence level.

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Exhibit 1

TEST METHOD FOR SOUTHERN CORN ROOTWORM ON CORN

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Test Site:--Any soil type and/or location where a natural infestation of the species occurs or is anticipated to occur.

Climatic Conditions:--Accept what occurs. Average or above average rainfall conducive to damage by the insect - along with a prolonged cool spring. All testing must be done by 1st to middle of May since damage to corn by this insect in Louisiana ceases at this time. Damage is confined to the seed in the ground before emergence and to the young seedling plant until it is approximately 5 to 6" (12.7-15.2 cm) high.

Test Crop:--Any adapted field corn hybrid or open pollinated field corn variety (ones usually grown in the area).

All seed are treated before planting with a fungicide; row spacing is usually 36-40 inches (.91-1.02 meters).

All tests are planted using a spacing chain and dropping one seed per 12 inches (30.5 cm) for a total of 100 seed per treatment replicate.

Plots are treated with atrazine at 2 1/2 lbs./A. (2.8 kg/hectare) immediately post planting. If soil compaction occurs later the plots may be lightly cultivated to provide a more desirable environment.

Insect:--Southern Corn Rootworm, Spotted Cucumber Beetle.

At time of treatment insect is in the larval stage (young) and the adult beetles are still laying some eggs (dependent on date of planting).

The larvae develop on the corn seed and young corn seedlings as well as grass, etc. About the time the corn plant is 5-6 inches (12.7-15.2 cm) in height, the larvae have matured and pupated (in the soil) and the newly emerged beetles begin to appear. Further damage to corn by this species does not normally occur in Louisiana. The adults may feed in a limited manner on the corn leaves, but they soon disperse - reportedly in a northward migration where the succeeding generations may feed on and cause damage to roots of growing corn in areas north of Louisiana.

Test Plot Management:--No special management procedures prior to planting. A field that was growing a green cover crop during the winter and spring prior to planting usually supplies a test site with a high infestation rate since the adults are attracted in early spring to the green cover crops. Also, use of an old pasture or sod field for the test usually insures an above average insect population.

All plots are fertilized as per the recommendations for the particular area for maximum corn yields. If possible, irrigation is employed when needed.

Procedures:--A Latin Square design may be employed or a randomized plot arrangement may be used. The plot arrangement selected is dependent on the local situation. Several test plot locations are desired in order to include as many different soil types and conditions as possible in order to more fully evaluate and understand the results obtained.

Individual plots (replicates) may be a single row 100 ft. (30.5 meters) long and containing 100 seed, or the plot may be as much as 3 or 5 rows wide each 100 ft. (30.5 meters) long. At least 2 or more border rows are used on each side of the experiment. Where more than one row is used in a replicate, the center row is employed as the record row - the remainder serving as border rows. The number of rows employed per replicate is dependent on field size and availability.

Treatment date(s) are same as planting dates.

A minimum of 4 replicates per treatment is used. On occasion where land is available the number of replicates may be increased to as many as 10. The usual number of replicates used is 4.

At present, the insecticide being investigated is formulated on sand as 10% sand granule. The particle size is very uniform and the product is free of foreign matter (rocks, strings, etc.). This material will flow by gravity from a definite size opening at a constant rate. Therefore, by using a proper-size opening and a uniform rate of walking it is possible to apply a desired amount of chemical in a definite length of row. Error in application is usually less than 5%. (This method of application is not applicable for applying granules formulated in clays.)

For actual use a one quart grain can is attached at an angle to the end of a 4-5 ft. (1.2-1.5 meters) stake. In the lid of the can (screw-type lid) is a smooth round hole (approximately 1/4" (.64 cm) in dia.). Size of hole opening is variable. Rate of chemical application may be controlled by either speed of walking or size of hole opening. Operator simply walks down the plot row at the desired speed with the can opening held a few inches above the opened row or drill which receives the chemical. Seed placement occurs immediately before or after the chemical is applied. The seed is then covered to desired depth using a single row planter with the opener removed.

Application of insecticide may be at time of planting either in the drill along with seed or post planting on soil surface immediately above the seed drill, or the chemical may be broadcast - either pre or post planting. Where a broadcast treatment is used a plot containing at least 5 rows is employed. A cyclone seed sower is used to apply the granules in this case and a minimum of 5 rows is needed to reduce effects of overlap.

An untreated control is always included in all tests as a basis for comparison or evaluating effectiveness of the treatments.

Infestation Procedures:--Only naturally occurring infestations are used.

Evaluations:--Evaluation of effectiveness of the various treatments are determined as follows:

Stand counts are made on 100 row ft. (30.5 meters) beginning at time plants are about 2" (5.1 cm) high and continuing at 2-3 day intervals until damage has ceased (plants 5-6" (12.7-15.2 cm) in height) at each examination all plants that are damaged by the rootworm are recorded and removed from the plot. (This procedure precludes double counting of a damaged plant.) When the plants average approximately 12" (30.5 cm) in height a plant height measurement is made. A total of 25 plants per replicate is measured to obtain the average plant height in each replicate.

From the above data the effectiveness of each treatment on plant stand and seedling vigor or growth is determined.

A yield (dry grain) record is made after the plants have matured and the grain moisture has reached 20%. From the yield figures the effectiveness of the treatments on production under the specific conditions of each test is made. Grain weights are based on 15 1/2% grain moisture. Yields are taken from the entire 100 ft. (30.5 meters) length of each plot.

The data may be subjected to standard procedures of analysis of variance.

Phytotoxicity:--All treatments are scored for phytotoxicity.

Exhibit 2

TEST METHOD FOR NORTHERN AND WESTERN CORN ROOTWORM ON CORN

D. D. Walgenbach
Associate Professor
Department of Entomology
South Dakota State University
Brookings, South Dakota

Site Selection:--Area must have uniform measurable edaphic factors. Soil type, pH, organic matter, exchange capacities, nitrate-nitrite measurements taken for comparative purposes.

Topography must be suitable for valid statistical design.

Field history on cropping sequence, herbicide and insecticide must be obtained.

Climatic Conditions:--Wind velocity and soil moisture conditions (surface) should be stated at time of application.

Test Crop:--Corn varieties must be listed and overall susceptibility to rootworm damage noted. Varieties do show differential responses to rootworm damage in either or both root regeneration and susceptibility to root rotting organisms.

Phytotoxicity measurements - The rate of plant emergence as well as total plants emerged are necessary for determining phytotoxic responses.

Row spacing, plant population and date of planting - insecticide application should conform to the area norms.

Test Plot Management:--Trap crops are necessary to insure both the adequacy and uniformity of infestation across test plots.

The trap crop should be harvested when the soil is firm to reduce compaction. Tillage operations should be minimal and timely to prevent rough seedbed and application surface.

Judicious use of herbicides to limit cultivations are necessary to prevent distortion of the insecticide band.

Procedures:--

Design - RCB, 4 replications, 5 samples per replicate.

Locations - Test plot locations should be in areas with exposure to different insecticides rather than one location with exposure to numerous compounds because of rootworm tolerance potential.

Plot Plan -

1. Row X 100 ft. (30.5 meters) with no samples taken 15 ft. from either end.
2. At least 2 border rows on each side of the plot.
3. Planting date must be earlier than May 20 unless unusual circumstances or a sequence of dates are involved.
4. Plot size should be limited to 15 treatments.

Treatment Procedures -

1. Application through metering device. Shaker acceptable under limited conditions.
2. Metering units must be calibrated under field conditions and recalibrated with changes in weather conditions.

Evaluations:--

Damage - (Hills and Peters, 1971, see previous methods).

Larval counts on a plant basis.

Yield determinations. Components must include distance and number of plants.

Exhibit 3

TEST METHOD FOR CUTWORMS ON CORN

Z. B. Mayo, Assistant Professor
Department of Entomology
University of Nebraska
Lincoln, Nebraska

Test Site:--Most tests are conducted on fields reported damaged by the insects not on predetermined fields.

Test Crop:--Varieties well adapted to the area.

Test Plot Management:--Normal production practices.

Procedures:--

Statistical Design - Randomized complete block with unit-subsampling.

Replications - Minimum of 4 replications.

Several locations preferred.

Specific plot plan -

1. Three or 4 row plots are used for each treatment. Each treatment is adjacent to an equal number of untreated rows. Fifty or 100 ft. (15.2-30.5 meters) long plots are used. Where 100 ft. (30.5 meters) long plots are used they are divided into 3 thirty ft. (9.1 meters) sub-units.
2. Minimum of 4 border rows.
3. Treatment dates - When infestations are located but before major damage has occurred.
4. Distance between replications - Minimum of 5 ft. (1.5 meters).

Specific treatment procedures -

1. Methods of application
    a. Granules - A hand operated applicator mounted on bicycle wheels with Noble metering units is used for band and broadcast applications. A 6 inch bander is used for band applications and a 14 inch bander for broadcast treatments.

   b. Liquids - A hand carried CO_2 or air pressurized sprayer is used for liquid applications.

2. Rate of application - Depends on material but usually is around 1-1 1/2 lbs. AI/Acre (1.1-1.68 kg/hectare) (40 inch (1.01 meters) row).

3. Stage of crop at treatment - Plant growth stages range from 1 to 2 based on the Iowa State University scale of corn growth stages.

4. Time of application - May 15 to June 15 in most years.

5. Due to extreme variation in cutworm infestations in a test area, each treatment is located next to an untreated row or rows.

Evaluations:--

Damage evaluations -

1. When plots are established the number of damaged and undamaged plants in each plot or 30 ft. (9.1 meter) sub-unit is recorded.

2. Ten days to 2 weeks later the number of damaged plants is checked again to determine % control.

3. Yields are taken in 20 ft. (6.1 meters) of row.

Analysis of Data - Standard Analysis of Variance used.

Effectiveness:--No specific known requirements. In most trials, yield must be increased by at least 15% to detect treatment effects. Stand losses in excess of 20% are considered economically damaged. To be highly effective, treatments must provide at least 75% control.

Phytotoxicity:--

Type -

1. Seed or seedling damage by planting time applications - No. plants/30' (9.1 meters) row.

2. Foliage damage by post-planting applications - % affected plants.

Reporting Procedures:--Most of the items listed are included in the report with the exceptions of compatibility with other products, presences and effects on wildlife and beneficial insects.

Exhibit 4

TEST METHOD FOR BLACK CUTWORM ON CORN

G. J. Musick, Associate Professor
Department of Entomology
The Ohio Agricultural Research and Development Center
Wooster, Ohio

Site Selection:--For natural infestations selections are restricted to those fields which have economic infestations. For tests using artificial infestations, selection is restricted to normal corn producing soils.

Crop and Plot Management:--A commercially adapted variety is planted at the row spacing and plant population consistent with the normal procedures of the cooperator and accepted agronomic practices (i.e., fertilization, etc.).

No special plot management techniques are employed except as necessary to maintain plot identification. Plots are planted parallel to existing corn rows to enhance fertilization and harvesting procedures.

Procedures:--The experimental design is consistent with the experimental objective and facilitates planting of the crop. Usually, randomized complete block or split plot designs are used.

Efficacy tests against black cutworm are conducted over several sites in a year or at one site over 2 or more years. The interaction of this pest with the environment makes this essential.

Plots for evaluation of efficacy are 4 rows wide by 15 ft. (4.5 meters) long (artificial infestation) or 4-6 rows wide by 50 ft. (15.2 meters) long (natural infestation). Plots are usually located in the center of a larger infested area to minimize border effects. Also sampling is restricted to the center 1/2 of the plot.

Applications of the insecticide is dependent on the infestation technique. With natural infestations, treatment is always after the economic infestation has been identified. For artificial infestations, generally, infestation follows treatment by about 1/2 day. For these latter tests, treatment dates are consistent with normal occurrence of the pest.

The methods for field application of insecticides for cutworm tests range from hand spreading of baits (preliminary tests of efficacy) to calibrated commercial field equipment (advanced development under field conditions). Formulations include sprays, granules and baits.

Insecticidal placement includes banding and broadcast of all formulations. Both placement are evaluated as preplant incorporated, postplant incorporated, and postplant unincorporated (especially baits).

Application rates range from 0.25 to 4.0 pounds AI/Acre (0.3 Kg. to 4.4 KG. AI/Hectare) for all placement and insecticides. Initial rates are as suggested from preliminary screening or commercial company recommendation. All tests include an untreated check and a standard recommended treatment in each replication.

Artificial Infestation Procedure:--After insecticidal application, barriers (6 inch (15 cm) aluminum lawn edging) are placed around the 2 center rows of each plot. The enclosed plot dimension is approximately 2 rows by 6 feet (1.8 meters). One barrier is placed in each treatment of each replication. After the barriers are in place, late 4th or 5th stage black cutworm larvae are released in the center of each plot at the rate of 1 larva/plant. Releases are usually during the late afternoon or early evening following treatment. These tests are conducted on corn that is between 2- and 4-fully emerged leaves with the ideal being the 2-leaf stage.

Evaluations:--For natural infestations, efficacy is measured by stand counts. Prior to treatment stand counts are made to establish the plant population. Approximately 3 days (range 2-6) after treatment stand counts are made and data reported as % stand reduction. Counts are repeated from 1-2 more times or until plant cutting ceases.

For artificial infestations, efficacy is measured by leaf feeding and various degrees of cutting (cutting at whorl, second leaf or at base of soil). Data are expressed as % cut plants or % of plants with cutworm damage (including leaf feeding). Evaluations are made every 2-3 days until cutting ceases.

The data are analyzed according to normal statistical procedures, and means separated by the Least Significant Difference (LSD), Duncan's New Multiple Range Test (DNMRT), or, if a factorial design, by orthogonal comparisons. Inferences are usually at the 0.05 level.

Phytotoxicity:--Notes on phytotoxicity are made as it is visibly evident. Stunting, loss of vigor, and stand reductions are normal indications. However, care is exercised to insure that it is phytotoxicity and not insect related damage.

Effectiveness:--Effectiveness is measured against an untreated check and a standard insecticide treatment. To be judged effective it must have values significantly higher than the untreated check while maintaining values near the standard insecticide. It must show no adverse phytotoxicity or no yield reduction.

Reporting Procedure:--Reports contain all pertinent information about the test and include information on the variety, pests, stage of pest, cooperator's name, location, insecticide (rate and formulation), planting date(s), evaluation date(s), plot size, row spacing, number of replications, soil type and performance. As available, information is furnished on weather conditions, compatibility with other insecticides, phytotoxicity, effects on non-target organisms and special comments on observations.

Exhibit 5

TEST METHOD FOR CUTWORMS ON CORN

J. J. Tollefson, Assistant Professor
Department of Entomology
Iowa State University
Ames, Iowa

Test Site:--

Insect Infestation - The study fields are selected on the basis of the actual population levels that are present. When a grower reports a serious infestation of one of these insects, the field is visited, the damage surveyed, and the population level of the insect estimated. If the insect is present in economic numbers, the stage of the insect is such that it will remain and continue feeding, and the farmer consents to allow a test plot to be located in his field, the original stand of corn will be disked out and the test established. The actual location of these tests is unknown until an infestation is reported.

In the case of cutworm infestations reported after it is too late to replant,rescue treatments may be applied. The existing plants will be used in these tests and the chemicals applied as dictated by the formulation and use practices. The rates for these tests cannot be selected until the infestation is reported and then the plots must be treated as rapidly as possible.

Topography - The test plots used are a single row wide. Consequently, appreciable soil movement due to erosion that may carry along the insecticides being evaluated cannot be tolerated. To avoid this, the area of a cutworm infested field that is selected for an insecticide evaluation study is located in an area of the field with minimum slope.

Border effects - The plots are positioned within a field so as to minimize border effects. The only restriction on the placement, other than slope mentioned previously, is that the plot must be readily accessible to farm equipment from at least one point.

Climatic Conditions:--The field evaluations of insecticides for the control of cutworms are designed to simulate typical agronomic practices and as such are subject to the same climatological restrictions as normal field work.

Test Crop:--

Variety - A commercially produced hybrid that has achieved wide acceptance by growers is used. If the field required replanting rather late in the year, the variety chosen is a shorter season variety grown by the northern portions of the region.

Row Spacing - The row spacing used by the cooperator is matched so that all tillage operations normally employed are also applied to the test plot.

Plant Population - A plant population considered about average for the state is used. This is not as dense a population as that used for rootworm evaluations because the late planted corn will be more likely to encounter moisture stress during the critical pollination period due to the later maturing date.

Test Plot Management:--

Plot management procedures to insure infestation - Plots are established where the insect has become established and is causing economic damage.

Planting procedures - The row spacing and direction of the cooperator are duplicated and the rows are aligned as closely as possible to those in the rest of the field. This allows all tillage practices employed after the plots have been established to be applied to the plots so that the tests are representative of typical agronomic practices.

Fertility procedures - The cooperator treats the plot area in exactly the same way up to planting time, using the same fertility procedures.

Procedures:--

Statistical design - Randomized complete block.

Replications - 4.

Locations required - An attempt is made to repeat the experiment at least once. This is dependent however on the availability of suitable insect infestations.

Specific plot plan -

1. Number and length of rows - The treatments with each replication are applied to a single row 100 ft. (30.5 meter) long.
2. Border effect - A minimum of four guard rows are planted on each side of the plot at the time the plot is planted and the plot is nested within a large field to avoid border effects.
3. Treatment dates - Treatments are applied as suitable fields become available.
4. Distance between replications - No evaluations are made in the first or last 15 ft. (4.6 meter) of a plot to allow for variability in the treatments due to the equipment starting and stopping.

Specific treatment procedures -

1. Methods - The methods and equipment used have been described in the publication:

   Hills, T.M., D.C. Peters, and W.G. Lovely. 1972. Application equipment and techniques used in the evaluation of granular insecticides for control of western corn rootworm larvae. *J. Econ. Entomol.* 65:1116-1119.

2. Rate of application - Rate of application depends on the formulation and toxicity of each specific insecticide.

3. Stage of crops at treatment - Crops are treated at planting time, except for cutworm rescue treatments in which the plants may be as large as growth stage 1.5, 6 leaves fully emerged.

4. Time of application - The chemicals are applied as needed depending on planting dates, weather conditions, and the insects which, acting together, will determine when the appropriate application time is. Normally these plots will be established from mid May through the middle of June.

5. Controls - A check (untreated) row and currently recommended treatments are included in each replication at all locations to serve as standards.

Infestation procedures -

Natural - Plots are located on land where economically damaging populations have been found.

Evaluations:--

Damage evaluations -

1. Plant stand - The amount of damage suffered by the crop is determined on the amount of stand reduction that results due to the feeding of the insect. The stand is determined by counting all the plants in 1/1000 of an acre in each replication. The average plant population is computed by taking the arithmetic mean of the stand counts for the 4 replications.

2. Yield - The average yield for each treatment at each location is computed by hand harvesting 1/1000 of an acre (1/2471 of hectare) for each treatment within each replication and computing the arithmetic mean of the 4 observations. The average is adjusted to yield per acre of No. 2 shelled corn based on its moisture content.

3. Insect - In addition to plant stand and yield evaluation, the numbers of living and dead insects are also counted to determine efficacy.

Evaluation interval -

1. Plant stand - The stand counts may be taken as soon as the plants are well established, 3-4 weeks following emergence.
2. Yield - The yields are determined as soon as the moisture content in the grain drops below 35%. This normally occurs during October or November.
3. Insect - At the same time stand counts are taken.

Analysis of data -

1. Procedures - Analysis of variance is used to determine if any differences occur between stands or between average yields within each location and also between the overall means computed using all locations. Differences between individual means are identified using Duncan's new multiple range test.

Probability level - $P < 0.05$.

Phytotoxicity:--

Evaluation - The average number of plants per 1/1000 of an acre (1/2471 of hectare) is determined for each treatment at each location.

Time interval - The time interval starts as soon as the plants have emerged and become well established, usually from mid to late June.

Analysis - Analysis of variance is used to determine if there are any differences between the means. Differences between individual means are identified using Duncan's new multiple range test.

Probability level - $P < 0.05$.

Effectiveness:--The minimum requirements for an insecticide to be judged effective is that it must consistently protect the plants from damage as well or better than the materials currently recommended while having no phytotoxic effects on the plant.

Reporting Procedures:—A preliminary report is prepared following stand count evaluations that include only statistical evaluations of the phytotoxicity and stand count data. A final report is issued after harvest that includes: a description of the evaluation procedures used; field data sheets that contain the descriptive information for each location; tables of means for the phytotoxicity, stand count and yield data with differences detected by Duncan's test identified for all locations and combined over locations when similar tests were conducted at more than 1 location; and tables containing daily maximum minimum temperature and precipitation data. The data included in the final report is complete enough to provide all the information requested by the EPA: lot or batch number of chemical compatibility of formulation with other products, presence of wildlife and beneficial insects, and effects on wildlife and beneficial insects.

Exhibit 6

TEST METHOD FOR WIREWORMS ON CORN

W. G. Genung, Professor
Agricultural Research and Education Center
Belle Glade, Florida

Site Selection:--In order to insure that tests will be on land with a suitable wireworm population, bait stations are established at predetermined space intervals, using nubbins or otherwise defective sweet corn ears or fermented corn-meal balls placed at depths of 3 to 6 inches (7.6-15.2 cm) (into zone of soil moisture). These bait stations are then checked in about 5-7 days for penetration or approach by wireworms. Lands previously in grass or graminaceous crops usually have heavy wireworm populations.

Soil Analysis:--After the test site is selected, soil samples are taken to determine pH and nutrient levels (including trace elements). Analysis is made by the Soils Section personnel and fertilization is based on this analysis.

Weed Control:--Since grass and weeds can dilute severity of soil insect attack on crop plants, good weed control is maintained. Either a pre-emergent herbicide application or manual cultivation is used to control weeds. Herbicide usage is based on the recommendation of the Plant Physiologist.

Transplantation of Wireworms:--In some cases, it has been found convenient to add wireworms from outside sources to under-populated experimental areas. By thus "sweetening" or "seeding" the plots with wireworms, satisfactory populations can be built up. In these cases, we add 10, 20, 30, to 50 or more wireworms to each plot prior to application of chemicals, the number depending on availability of material for transplantation. The wireworms collected for this purpose are kept in buckets of moist soil until ready for transplantation. Addition of a suitable food material will prevent any serious degree of cannibalism among the confined larvae.

Plot Size:--4 rows, 3 ft. (0.9 meter) between rows, 25 ft. (7.6 meters) long. An unplanted and untreated buffer zone of 12' (3.6 meters) is maintained between plots and blocks.

No. Replications:--Usually 4, occasionally 3 or 5. A randomized complete block design is used.

Soil Type:--Everglades peat and muck, about 80 to 85% organic matter.

Formulations:--Granules, WP, EC.

Rate of Application:--As a rule-of-thumb, we start with 4.00 lbs AI/A (4.5 kg/hectare) on organic soil unless advised by manufacturers to use less or more.

Time of Application/Crop Stage:--(a) Pre-plant (2 wks before planting) broadcast or, (b) in the row at planting. In recent years, we have largely used (b) above, as the growers have resisted using (a) above.

Stage of Crop and Insect at Application:--Crop: not planted or in seed stage. Insect: in larval stage.

Method of Application:--(a) broadcast 2 weeks pre-plant or (b) in the row at planting.

Interval/Treatment to Observation:--Observations are commenced as soon as germination is completed. a) a stand count is first made, then, b) stand loss counts are commenced as follows: When a wilted plant is found, that plant is immediately dug out to determine the cause. If it is killed by a wireworm, cutworm, lesser cornstalk borer, or other subterranean insects, then, this is recorded. It can then be determined what percent stand loss occurred as a result of wireworm, cutworm, etc., attack. Counts are made at daily intervals until plants are about a foot high. The cumulative percent stand loss caused by the various species can then be computed for the different treatments.

Interval Between Observations:--Observations are made daily.

Yields:--Yields may or may not be taken. If taken, these are expressed in crates/acre.

Pertinent Comments:--Because of the tremendous buffering action of these Florida organic soils, normally amounts of insecticides to be incorporated therein, must be doubled to get control equivalent to half that amount on mineral soils.

Phytotoxicity:--As given on report forms, any burn, discoloration, distortion, or retardation or reduction in germination as a result of treatments is noted after comparison with untreated checks.

Sample data sheets of some recent corn tests are included.

Exhibit 7

TEST METHOD FOR WIREWORMS ON CORN

Z. B. Mayo, Assistant Professor
Department of Entomology
University of Nebraska
Lincoln, Nebraska 68503

Test Site:--Test sites are selected on the basis of (1) number of wireworms in corn baits, (2) previous history of wireworm problems and (3) land only 1 or 2 years out of sod. Preferably, plots are placed in fields with an average of over 5 wireworms/bait (baited either in the spring or fall) and or on land with a serious wireworm problem the previous year.

Climatic:--No specific requirements but cool wet springs are considered conducive to increased damage.

Test Crop:--No specific requirements. Normal production practices.

Test Plot Management:--Normal production practices.

Procedures:--

Statistical design or designs - Randomized complete block with unit subsampling.

Replications - A minimum of 4 replications.

Due to problems associated with wireworm studies, several locations are preferred.

Specific plot plant -

1. One row plots at least 100 ft. (30.5 meter) long are used for band and in-furrow insecticide comparisons. If broadcast treatments are used, 3 or more rows are used for each treatment depending on equipment available. Each treatment row per replication is divided into 30 ft. (9.1 meter) sub-units for evaluation. Each treatment is adjacent to an untreated row or rows.
2. Minimum of 4 border rows.
3. Treatment dates - Early planting times are preferred (April 25 to May 15).

4. Distance between replications - Minimum of 5 ft. (1.5 meter).

Specific treatment procedures - Same as described for rootworms with minor modifications in some instances.

Controls - Due to extreme variation in wireworm populations in a test area, each treatment is located next to an untreated row or rows.

Evaluations:--

Damage evaluations -

1. Approximately two weeks after planting the number of plants in each 30 ft. (9.1 meter) sub-unit are counted.

2. At the same time, the number of skips (places where it is judged that a plant should be) are counted.

3. Each skip is dug to recover the seed to determine if it has (1) been damaged by wireworms, (2) failed to germinate but no feeding damage apparent, or (3) no seed was planted.

4. Number of damaged plants (with whorl wilting) are counted and dug to determine if wireworms are feeding on the stem below ground.

5. Number of wireworms, if present, per skip or damaged plant are counted.

6. Ten days to 2 weeks later, the plants in each 30 ft. sub-unit are examined again to see if any additional damage has occurred.

7. All damaged seeds and plants per 30 ft. (9.1 meter) sub-unit for both counts are totaled to determine percent damaged.

8. Yield - Yield is taken in 20 ft. (6.1 meter) of row from each treatment if damaging populations were present.

Analysis of data -

1. Analysis procedure - Standard analysis of variance and Duncan's Multiple Range tests are conducted on the average of the sub-units per replication.

   In addition, each 30 ft. (9.1 meter) sub-unit of a treatment is analysed (using a T test) against the untreated rows adjacent to it.

Also, all treatments with similar damage in the adjacent untreated rows are compared to each other.

2. Tests are analyzed at the .05 level.

Phytotoxicity:--

Type -

1. Seed or seedling damage by planting time applications - No. plants/30' (9.1 meters) row.
2. Foliage damage by post-planting applications - % affected plants.

Effectiveness:--No specific known requirements. In most trials, yield must be increased by at least 15% to detect treatment effects. Stand losses in excess of 20% are considered economically damaged. To be highly effective, treatments must provide at least 75% control.

Reporting Procedures:--Most of the items listed are included in the report.

Exhibit 8

TEST METHOD FOR WIREWORMS ON CORN

J. J. Tollefson, Assistant Professor
Department of Entomology
Iowa State University
Ames, Iowa 50010

Test Site:--

Insect infestation - The study fields are selected on the basis of the actual population levels that are present. When a grower reports a serious infestation of one of these insects, the field is visited, the damage surveyed, and the population level of the insect estimated. If the insect is present in economic numbers, the stage of the insect is such that it will remain and continue feeding, and the farmer consents to allow a test plot to be located in his field, the original stand of corn will be disked out and the test established. The actual location of these tests is unknown until an infestation is reported.

Topography - The test plots used are a single row wide. Consequently, appreciable soil movement due to erosion that may carry along the insecticides being evaluated cannot be tolerated. To avoid this, the area of a wireworm infested field that is selected for an insecticide evaluation is located in an area of the field with minimum slope.

Border effects - The plots are positioned within a field so as to minimize border effects. The only restriction on the placement, other than slope mentioned previously, is that the plot must be readily accessible to farm equipment from at least one point.

Climatic Conditions:--The field evaluations of insecticides for the control of wireworms are designed to simulate typical agronomic practices and as such are subject to the same climatological restrictions as normal field work.

Test Crop:--

Variety - A commercially produced hybrid that has achieved wide acceptance by growers is used. If the field requires replanting rather late in the year, the variety chosen is a shorter season variety grown by the northern portions of the region.

Row spacing - The row spacing used by the cooperator is matched so that all tillage operations normally employed are also applied to the test plot.

Plant population - A plant population considered about average for the state is used. This is not as dense a population as that used for rootworm evaluations because the late planted corn will be more likely to encounter moisture stress during the critical pollination period due to the later maturing date.

Test Plot Management:--

Plot management procedures to insure infestation - Plots are established where the insect has become established and is causing economic damage.

Planting procedures - The row spacing and direction of the cooperator are duplicated and the rows are aligned as closely as possible to those in the rest of the field. This allows all tillage practices employed after the plots have been established to be applied to the plots so that the tests are representative of typical agronomic practices.

Fertility procedures - The cooperator treats the plot area in exactly the same way up to planting time, using the same fertility procedures.

Weed control - The necessary herbicides to provide weed control will usually have been applied when the original plant stand was established. If any additional measures are taken subsequent to the establishment of the plot, the research area is treated in the same way as the rest of the field.

Procedures:--

Statistical design - Randomized complete block.

Replications - 4.

Locations required - An attempt is made to repeat the experiment at least once. This is dependent however, on the availability of suitable insect infestations.

Specific plot plan -

1. Number and length of rows - The treatments within each replication are applied to a single row 100 ft. (30.5 meters) long.
2. Border effect - A minimum of four guard rows are planted on each side of the plot at the time the plot is planted, and the plot is nested within a large field to avoid border effects.
3. Treatment dates - Treatments are applied as suitable fields become available.
4. Distance between replications - No evaluations are made in the first or last 15 ft. (4.6 meters) of a plot to allow for variability in the treatments due to the equipment starting and stopping.

Specific treatment procedures -

1. Methods - The methods and equipment used have been described in the publication:

   Hills, T.M., D.C. Peters, and W.G. Lovely. 1972. Application equipment and techniques used in the evaluation of granular insecticides for control of western corn rootworm larvae. *J. Econ. Entomol.* 65:1116-1119.

2. Rate of application - Rate of application depends on the formulation and toxicity of each specific insecticide.

3. Stage of crops at treatment - Crops are treated at planting time, except for wireworm rescue treatments in which the plants may be as large as growth stage 1.5, 6 leaves fully emerged.

4. Time of application - The chemicals are applied as needed depending on planting dates, weather conditions, and the insects which, acting together, will determine when the appropriate time is. Normally these plots will be established from mid-May through the middle of June.

5. Controls - A check (untreated) row and currently recommended treatments are included in each replication at all locations to serve as standards.

Infestation procedures -

1. Natural - Plots are located on land where economically damaging populations have been found.

2. Trap crops - Not used.

Evaluations:--

Damage evaluations -

1. Plant stand - The amount of damage suffered by the crop is determined on the amount of stand reduction that results due to the feeding of the insect. The stand is determined by counting all the plants in 1/1000 of an acre (1/2471 of a hectare) in each replication.

   The average plant population is computed by taking the arithmetic mean of the stand counts for the 4 replications.

2. Yield - The average yield for each treatment at each location is computed by hand harvesting 1/1000 of an acre (1/2471 of a hectare) for each treatment within each replication and computing the arithmetic mean of the 4 observations. The average is adjusted to yield per acre of No. 2 shelled corn based on its moisture content.

3. Insect - In addition to plant stand and yield evaluation, the numbers of living and dead insects are also counted to determine efficacy.

Evaluation interval -

1. Plant stand - The stand counts may be taken as soon as the plants are well established, 3-4 weeks following emergence.

2. Yield - The yields are determined as soon as the moisture content in the grain drops below 35%. This normally occurs during October or November.

Analysis of data -

1. Procedures - Analysis of variance is used to determine if any differences occur between stand counts or between average yields within each location and also between the overall means computed using all locations. Differences between individual means are identified using Duncan's new multiple range test.

2. Probability level - P 0.05.

Phytotoxicity:--

Evaluation - The average number of plants per 1/1000 of an acre (1/2471 of a hectare) is determined for each treatment at each location.

Time interval - The time interval starts as soon as the plants have emerged and become well established, usually from mid-to late June.

Analysis - Analysis of variance is used to determine if there are any differences between the means. Differences between individual means are indentified using Duncan's new multiple range test.

Probability level - P 0.05.

Effectiveness:--The minimum requirements for an insecticide to be judged effective is that it must consistently protect plant stand as well or better than the materials currently recommended while having no phytotoxic effects on the plant.

Reporting Procedures:--A preliminary report is prepared following stand and insect evaluations that include only the statistical evaluations of the phytotoxicity and stand and insect data. A final report is issued after harvest that includes: a description of the evaluation procedures used; field data sheets that contain the descriptive information for each location; tables of means for the phytotoxicity, stand counts and yield data with differences detected by Duncan's test identified for all locations and combined over locations when similar tests were conducted at more than 1 location; and tables containing daily maximum minimum temperature and precipitation data. The data included in the final report is complete enough to provide all the information requested on the EPA list required for registration except: lot or batch number of chemical, compatibility of formulation with other products, presence of wildlife and beneficial insects, and effects on wildlife and beneficial insects.

Exhibit 9

INSECTICIDE TEST METHOD FOR SOUTHERN CORN ROOTWORM ON PEANUTS

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The southern corn rootworm *Diabrotica undecimpuncta howardi* Barber adults feeds on the unopened quadrifoliate leaves during June, July, and August. Adult damage is of minor importance.

Adults commence to oviposite in late July and continue until harvest. Adults reach a peak in numbers on peanuts in North Carolina during the first 10 days in August (ovipositing adults) and the third week in September (emerging adults).

Single and multiple sprays for adult control have not been satisfactory. The best control has been obtained with granular insecticides applied after pegging and before mid-August in North Carolina.

Site Selection:--Tests are established in silt loam and sandy loam soils having an organic matter content of 2% to 5.5%.

Commercial Virginia type peanuts *Arachis hypogaea* are utilized, such as 'Florigiant,' 'NC 2', 'NC 5', or 'shulamit'.

Procedures:--

Statistical design - Randomized complete block or split plot design.

Replications - 3 replicates.

Plot size - 4 rows x 30 ft. (9.1 m).

Row spacing - usually 36 inches (91.4 cm).

Application equipment - Gandy 901-2 granular row applicator.

Application method - Granules are applied in an 18-inch (45.7 cm) band over the row and incorporated into soil 1 to 2 inches (2.5-5 cm) with a rotary hoe except when excess vine growth does not permit incorporation.

Time of application - Apply at pegging time (about 60 days post planting) to 30 days post pegging.

Controls - Untreated control and a standard insecticide treatment should be included for relative efficacy.

Evaluation:--

Sample Size - Select at random 5 plants from each plot, remove all pegs and pods and count the number penetrated by the rootworm. Interval between treatment and damage evaluation - 60 days after pegging application or 30 to 45 days after post-pegging application or approximately 20 to 40 days prior to harvest.

Calculation % damage - use the formula:

$$\% \text{ damage} = \frac{\text{No. rootworm damaged pegs + pods}}{\text{Total no. pegs + pods}} \times 100$$

Yields - Harvest entire plot or at least two rows, field cure or artificially cure, and weigh. Weight may be converted into lb/acre (kg/hectare).

Effectiveness:--Candidate insecticides should compare favorably with those currently registered.

Exhibit 10

INSECTICIDE TEST METHOD FOR THRIPS CONTROL ON PEANUTS

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The tobacco thrips *Frankliniella fusca* Hinds attacks peanuts from the time they crack the ground until mid-season in North Carolina.

Thrips oviposit in the leaves and petioles and immature thrips develop within the unopened quadrifoliate leaves. When the leaflets unfold, damaged leaflets are scared and malformed. If thrips attack very young leaves, the leaves have a burned appearance.

Peanut varieties differ in susceptibility to thrips injury. Variety-insecticide interactions are common and may have a profound effect on the efficacy of an insecticide, especially systemic soil-applied insecticides (1).

Test Plot Management:--Locate the test on the edge of a field with a weedy border or adjacent to alternate host.

Procedures:--

Statistical design - Randomized complete block or split plot design for interaction studies.

Replications - 3 replicates or more.

Plot size - 1 to 4 rows x 30 ft. (9.1 m).

Row spacing - Usually 36-inch (91.4 cm) rows.

Formulation - Granular or liquid systemic insecticide.

Application equipment - Gandy 901-2 row applicator, or sprayer, or equipment for soil injection of liquids.

Application method - Systemic insecticides are applied in the opened seed furrow at planting time. The peanut seed are planted in the furrow with the insecticide. Insecticides must be in the immediate zone of the seed for efficient uptake of the systemic insecticide.

Control - Untreated control at least one standard insecticide treatment should be included for relative efficacy.

Evaluation:--

Sample size (thrips) - Select from center of the plot one terminal leaf from 5 plants in each of the two center rows. Record the number of thrips from the 10 plant terminals.

Sample size (thrips damage) - Count the number of thrips-damaged leaves on one center row. (Minimum 20 ft. or 6.1 m).

Interval between treatment and evaluation -

1. Thrips counts - At weekly intervals or 30 to 45 days post planting.
2. Thrips damage - At weekly intervals or 45 to 60 days post planting.

Yields - Harvest the entire plot or at least two rows.

Effectiveness:--Candidate systemic soil-applied insecticides should compare favorably with those insecticides currently registered for thrips control.

Reference

1. Campbell, W. V., D. A. Emery, J. C. Wynne, and R. W. Bates. 1975. Interaction of peanut variety and insecticides. *J. Am. Peanut Res. Ed. Assoc.* 7:(Abstract).

Exhibit 11

INSECTICIDE TEST METHOD FOR POTATO LEAFHOPPER CONTROL ON PEANUTS

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The potato leafhopper *Empoasca fabae* Harris is a mid-season to late-season pest of peanuts. Feeding by the leafhopper on peanuts results in a "V"-shaped yellowing of leaves at the tip. This yellowing or "hopperburn" may cause the leaves to shed prematurely.

Peanut varieties differ in susceptibility to leafhopper injury. Variety-insecticide interactions have been observed which affect the efficacy of soil-applied systemic insecticides (1).

The potato leafhopper overwinters in the Gulf coast region and migrates to North Carolina in June. The population peak in North Carolina occurs in late July and early August. Since damage or "hopperburn" is accumulative, damage is most evident during August and September. The leafhopper population decreases after mid-August.

Site Selection:--Locate the test on the edge of a field to obtain more uniform population of leafhoppers. Select a field with sufficient width to permit one range per replicate.

Procedures:--

Statistical design - Randomized complete block or split plot design for interaction studies.

Plot size - Minimum 4 rows X 20 to 40 ft (6.1 to 12.2 m).

Replications - At least 3 replicates.

Soil type - Soil type affects phytotoxicity. Phytotoxic symptoms are more severe on peanuts grown in light, sandy soil than on peanuts grown in heavier soils.

Formulation - Any granular or liquid systemic insecticide with particles size that permits accurate calibration of granular row applicators.

Time of application - Apply systemic insecticide in the seed furrow at planting time. Non systemic and systemic granular formulation applied at pegging time for the southern corn rootworm efficacy studies also provide differential control of the potato leafhopper.

Method of application - Apply at planting granular systemic insecticide with a Gandy 901-2 row applicator, or tractor mounted granular row applicator, or any method that will uniformly and accurately distribute the granules or liquids in the seed furrow. Apply at pegging time (early July in North Carolina) granular insecticides, as for southern corn rootworm control, in a 16 to 18 inch (40.6 to 45.7 cm) band over the row with a granular row applicator.

Controls - Untreated control plot and one standard insecticide treatment should be included for comparative efficacy.

Evaluation:--

Sample size - Count the number of leafhopper adults and nymphs on 10 plants in the two center rows of each plot, or the number collected per 10 ft (3.0 m) row (minimum) by D-Vac , or number collected in 10 net sweeps, or count the number of leaves with "hopperburn" on one entire center row of each plot, or determine by a visual estimate the % "hopperburned" leaves in the two center rows of each plot for seasonal control.

Interval between treatment and evaluation - Leafhopper counts may be taken at the population peak (late July) or approximately 10 weeks post treatment (planting). Leafhopper damage evaluation may be taken 10 to 15 weeks post planting (treatment). Residual seasonal control may best be determined by evaluating leafhopper damage 14 to 15 weeks post treatment (late August in North Carolina).

Calculation for efficacy - May be converted into % control or % reduction in damage and analyzed by standard analysis of variance.

Yields - Harvest entire plot or at least two rows, cure the peanuts, weigh, and grade when feasible.

Effectiveness:--Candidate granular insecticides should compare favorably with insecticides currently registered.

Reference

1. Campbell, W. V., D. A. Emery, J. C. Wynne, and R. W. Batts. 1975. Interaction of peanut variety and insecticides. *J. Am. Peanut Res. Ed. Assoc.* 7:(Abstract).

Exhibit 12

PROCEDURES FOR TESTING INSECTICIDES AGAINST SUGARBEET ROOT MAGGOT

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Procedures:--

Replications - 4 to 6.

Plot size - 2, 3, or 6 rows wide by 50-100 feet long.

Method of application - tractor-mounted experimental applicator. Six metering devices each with a delivery tube to the row. Materials delivered variably at planting in relation to seed: above, below, to the side, or over the row in 4-5-inch bands and incorporated. At post-emergence, applied in bands over the row and lightly incorporated.

Time of application - at seeding to post-emergence (up to 6-leaf stage).

Evaluations:--

Stand counts - are sometimes made before and after thinning.

Maggot counts - are sometimes made at mid-season when most maggots are mature (usually mid-July in central Idaho). These are made by sifting soil from 4- to 6-inch cores surrounding beets and expressed as number of maggots/beet.

Damage ratings - these are made on a scale of 0-5 at mid-season.

Yields - these are taken at harvest in October-November.

Effectiveness:--Determined by comparison with untreated checks.

Exhibit 13

TEST METHOD FOR DETERMINING FIELD EFFICACY OF SOIL INSECTICIDES FOR CONTROL OF SUGARBEET ROOT MAGGOTS

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The sugarbeet root maggot, *Tetanops myopaeformis* (Röder) is one of the major soil insect pests in many areas where sugar beets are grown. Yield losses may range from 3 to 15 tons per acre. The most effective method of control is through the use of soil insecticides to kill the larvae or maggots in the soil.

Test Site Selection:--Fields of sugar beets that have been in beets for the previous two years or more are preferred. Generally infestations are heaviest on sandy or sandy loam soils.

Test Plot Management:--Plot management techniques are usually the same as those employed for normal sugarbeet production.

Test Procedures:--The standard statistical or experimental designs are used. Usually a randomized complete block design is used but depending on the objectives of the experiment, a split plot or other design might be better suited.

Generally 4 replications are adequate, but 4 to 6 are frequently used.

Size of plot may also vary, but a single row plot 25 to 50 feet in length is adequate. A plot 2 to 6 rows wide may be desirable depending on available equipment.

Method of application involves the use of granule applicators mounted on planters. Granular insecticides are applied in a 4-6-inch band over the row and incorporated lightly with either power incorporators, finger weeders, scratchers, or dragging a chain. Other methods may include in-furrow applications.

Time of application may vary. Most applications are made at planting time. However, postemergence applications may also be made and if so, are usually timed to be applied 1 week after first fly emerges (especially in Wyoming) or when the plants are in the 4-8-leaf stage.

Evaluations:--To evaluate the efficacy of soil insecticides for control of sugarbeet root maggots, technique criteria should include stand counts, maggot counts, damage classification, yield, and observations or measurements on phytotoxicity.

Stand counts should involve the following from 25, 50, or 100 feet of row per treatment per replication:

Early stand count - taken shortly after plant emergence but prior to thinning to determine what, if any, phytotoxicity or effect on germination and seedlings exists from insecticides used.

Immediate post-thinning stand count - taken immediately following thinning to establish a basic stand count for the season, prior to any seedling loss to maggots.

Mid-season stand count - this should be taken after most of stand loss due to maggots has taken place.

Comparing the 2nd and 3rd stand count gives reduction of stand due to maggots.

Maggot counts should be taken the second or third week in July (in Wyo.). Sugar beets (4 to 10 per treatment per replication) should be dug. Examine beet and soil within a 2-inch radius of beet to a depth of 8-10 inches. Count and record as number of maggots per beet.

Damage evaluations on roots (beets) can be made on the same beets dug for maggot counts. The classes of damage rank from 1 to 5 and are defined as follows:

Class 1 - no damage.

Class 2 - light damage; occasional small feeding scars.

Class 3 - moderate damage; numerous small feeding scars but no tip damage.

Class 4 - heavy damage; growing tip damage and/or heavy feeding scars.

Class 5 - severe damage; tap root severed, severe feeding scars, plants dead or nearly dead or will die.

The root or beet damage classification is the most stable and most reliable criterion.

Yield data consist of harvesting a single row 25 to 50 feet in length per treatment per replication. Although size of plot may vary, data recorded should include number of beets per acre, tons of beets per acre, and/or pounds of sugar per acre.

Effectiveness:--In all categories of evaluations experimental treatments are compared with standard treatments and untreated checks. Percent control is based on treatments versus untreated checks. The data are analyzed according to standard analysis of variance procedures. Differences among treatment means are determined by numerous methods such as LSD Duncan's New Multiple Range Test, etc.

Exhibit 14

METHODS TO EVALUATE INSECTICIDES FOR SUGARBEET ROOT MAGGOT CONTROL

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Test site:--Tests are established in beet fields having a silty loam to silty clay loam type of soil.

Procedures:--

Replications - 7 to 12.

Plot size - 6 rows (22 inches between rows) wide; 100 feet long; 4 center rows in each plot tested.

Method of application - materials are applied in 7-inch bands over the row and incorporated into the soil with 1 3/4-inch drag chains; or applied into the furrow.

Time of application - a) in-the-furrow at planting, b) band over the row at planting time, and c) band over the row when plants are in the 4-6-leaf stage.

Evaluations:--

Yields - yields are taken from 30 feet of beet row from row 3 in each plot at harvest time (late September to mid-October).

Effectiveness:--Percent control is determined by comparing yields in tons per acre in treated beets with untreated beets.

Exhibit 15

METHODS OF INSECTICIDE TESTING FOR SUGARBEET ROOT MAGGOT CONTROL

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Great Western Sugar Company
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Test site:--To be established in beet fields where soil is usually a sandy loam with 2% organic matter.

Procedures:--

Statistical design - randomized complete block, split plot, factorial, paired "t" test.

Replications - 4 to 6.

Plot size - 2 rows wide and 25 feet long for initial screening test and 4 rows wide and 50 feet long for advanced performance test.

Method of application - applied with application equipment to portions of field treated (in-furrow, band, or broadcast), and incorporated with power incorporation, scratchers, side dress, etc.

Time of application - preplant, at planting, preemergence and postemergence.

Evaluations:--

Phytotoxicity - ratings from 1-5 where 1 = no damage or best, and 5 = serious damage or worst.

Stand counts - number of beets per 40 to 80 ft row/plot or 2 ft/row for 2 rows in 25 ft plots.

Maggot counts - number of insects/5 beets/plot (20 beets/plot for strip trials).

Root ratings - on a 1-5 scale where 1 = no damage or best and 5 = serious damage or worst.

Yields - in tons per acre, percent sucrose and pounds of sugar per acre.

Effectiveness:--Effectiveness is expressed in percent control by comparing treatments with untreated checks.

Exhibit 16

INSECTICIDE TEST METHOD FOR FLEA BEETLE ON TOBACCO

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Insect Pest:--

Common name - Tobacco flea beetle.

Scientific name - *Epitrix hirtipennis* (Melsheimer).

Newly set tobacco plants are especially vulnerable to attack by overwintering adults of the tobacco flea beetle and high populations of the 2nd generation may severely damage leaves on the lower third of the mature plant. In addition, larvae feed upon tobacco roots and may severely damage newly set plants (2).

Test Plot Management:--

Test site - Locate test near flea beetle overwintering sites near a woodlot or an old field.

Procedures:--

Statistical design - Randomized Complete Block.

Replications - 3 or more replicates.

Plot size - 6 rows wide and 24 ft. long with an uncultivated border strip 8 ft. wide separating plots on all sides (Dominick, 1971).

Row spacing - 48-inch (1.2 m) rows.

Plant spacing - 20 inches (50.8 cm).

Application Equipment:--

Broadcast - Apply granules with a hand applicator. Emulsifiable concentrates are diluted in water and applied with a single nozzle sprayer. Following application, disk the materials into the soil to a depth of ca. 4 in. or 10.1 cm (4).

Band Application - Infurrow granules and sprays are placed in a 12 inch (30.4 cm) band with hand applicators in advance of a fertilizer-applicator row lister (4).

Control - Untreated check and at least one standard should be included for comparative efficacy.

Evaluation:--

Sample Size - Flea beetles damage on newly set tobacco is evaluated by counting feeding punctures on the seriously damaged leaves from each of 6 randomly selected plants in the 2 center rows of each plot. Late season control is determined by counting all beetles on 6 random plants from the 2 center rows of each plot (3).

Interval between treatment and evaluation - The most damaged leaf from each of 6 randomly selected plants in the two center rows of each plot are removed 14 days after transplanting to determine the number of flea beetle punctures. Late season evaluation is determined by making population counts at weekly intervals beginning 4 weeks after transplanting and continuing until early August (1).

Analysis of data - Data are subjected to ANOVA and Duncan's Multiple Range test.

Effectiveness:--Candidate soil systemic insecticides should be as effective or more effective than chemicals currently recommended for tobacco flea beetle control. Phytotoxicity and tobacco quality ratings are necessary for registration of a new soil insecticide.

References

1. Dominick, C. B. 1965. Experiments with insecticides applied in the soil for tobacco flea beetle and green peach aphid control. *J. Econ. Entomol.* 58(2):224-5.

2. Dominick, C. B. 1967. Systemic insecticides applied to the soil for control of the tobacco flea beetle on tobacco. *J. Econ. Entomol.* 60(5):1468-9.

3. Dominick, C. B. 1969. Evaluation of insecticides for tobacco flea beetle control. *Tob. Sci.* 13:164-5.

4. Dominick, C. B. 1971. Evaluation of systemic insecticides for green peach aphid control on tobacco. *J. Econ. Entomol.* 64(6):1565-6.

Exhibit 17

METHOD OF TESTING CHEMICALS FOR EFFICACY AGAINST THE CABBAGE MAGGOT, *HYLEMYA BRASSICAE* (BOUCHE)

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In screening chemicals for activity against the cabbage maggot, *Hylemya brassicae*, purple-top, globe turnips are used as the host plant to be protected for several reasons: the growth period of about 60 days is long enough to allow for attack by at least one generation of the maggot, but short enough so that 2 tests can be run during a single growing season if desired; evaluation of results can be conducted in the field by a 2 man team in a relatively short period of time; and because good performance in a test of this sort would indicate great promise for the material for protection against the maggot on other root and stem cruciferous crops.

The procedure is as follows: the land is prepared (worked down to seed-bed tilth) and then rows marked and fertilized using tractor equipment; single-row, 20-foot plots are marked off in replicated blocks (usually 4); granular chemicals in measured amounts are applied to the surface of the soil by hand in a narrow band (2-1/2" wide) along the marked rows using a jar with perforated metal screw-cap; turnip seed is planted along the rows with a Planet, Jr.^{R} hand planter equipped with side-sweeps to return displaced granules and soil to be compressed by the packer wheel; and seedling stand counts may or may not be taken (as an indication of phytotoxicity). Liquid insecticides are tested by diluting the concentrates so that 1 pint of liquid per 20 foot plow-row will contain the amount of chemical desired. Coarse drenching sprays are directed along the rows after the turnips have reached the 1 or 2 leaf stage (20 or more days after planting). Compressed air hand sprayers can be calibrated to accomplish this rate of application. The rates of active ingredient most often used are 1.0 and 1.5 ounces AI/1000 feet of row (equal to 0.91 and 1.35 lbs AI/acre at 36" row spacing). The plots are irrigated (overhead sprinklers) and cultivated for 60 days or until the roots are of marketable size. Sampling is done by an assistant, who selects and pulls 25 roots from each plot according to their marketable size. The roots are examined in the field by the investigator and classified for degree of maggot injury (called Control Rating) according to the following categories:

Clean, where no maggot injury is discernible;
Slight, with a few minor surface injuries, or injury confined to the tap root distinct from the edible portion;
Moderate, with 1-2 well-defined maggot tunnels; and
Heavy, with 3 or more established maggot tunnels.

The Control Rating itself is obtained by multiplying the numbers of Clean turnips by a factor of 4; those with Slight injury by 2; Moderate by 1; and those with Heavy injury by 0. With 25 roots examined per plot, and 4 replications, the highest Control Rating possible would thus be 100 - analogous to "100% Control".

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